MUDDY MOUNTAINS G-E-M RESOURCES AREA

(GRA NO. NV-34)

TECHNICAL REPORT

(WSA NV 050-0229)

Contract YA-554-RFP2-1054

Prepared By

Great Basin GEM Joint Venture
251 Ralston Street
Reno, Nevada 89503

For

Bureau of Land Management
Denver Service Center
Building 50, Mailroom
Denver Federal Center
Denver, Colorado 80225

Final Report

May 6, 1983

TABLE OF CONTENTS

Table of Contents cont.

Table of Contents cont.

Table of Contents cont.

Page

LIST OF ILLUSTRATIONS

EXECUTIVE SUMMARY

The Muddy Mountains Geology-Energy-Minerals (GEM) Resource Area (GRA) includes the following Wilderness Study Area (WSA): WSA NV 050-0229. The Muddy Mountains GRA is located in northeastern Clark County, Nevada approximately 12 miles northeast of Las Vegas.

The WSA includes 200 million years and older carbonate rocks forming the higher elevations, clastic sandstones and carbonates from 140 to 200 million years old, and younger sediments at the lower elevations. The geologic structure of the area is complex.

The Muddy Mountains as a whole is considered one of the most promising locations for potential nonmetallic mineral resources of any of the GRAs investigated for the Great Basin Region during this study. There are no known metallic mineral occurrences in the GRA or the WSA. There are deposits which are or have previously been mined for nonmetallic mineral resources in the GRA, including gypsum and clay in the west, borate minerals to the southeast and northeast, and silica in the north. The clay and the silica deposits are within the WSA. Additional nonmetallic mineral occurrences in the GRA and the WSA include silica, gypsum, colemanite, clay, chalcedony or agate, glauberite and limestone.

Patented claims are found at the two borate mines and the gypsum mine. Two patented claims are found covering the Vanderbilt clay deposit within the WSA. There are abundant unpatented claims for the above mentioned commodities throughout the GRA. Unpatented claims within the WSA are covering silica along the north border of the WSA, silica and borates along the south border, and perhaps some gypsum claims in the vicinity of the Pabco gypsum mine on the west. Oil and gas leases cover the entire GRA, but there are no geothermal leases.

There is no indication of favorability of metallic minerals resources in the WSA except for along the western boundary where it is considered low for manganese with a low confidence level.

Nonmetallic mineral resources are abundant in the GRA and reflect the potential within the WSA. Borates, gypsum and sand and gravel have a high favorability on the fringes of the WSA with a high confidence level. The area surrounding the clay deposit inside the WSA also has a high favorability with a high confidence level. The remainder of the WSA has a moderate favorability with a moderate confidence level for such commodities as borates, lithium, zeolites, clay, silica, building stone, limestone, sand and gravel and gypsum.

Uranium has a very low to low favorability with a very low to low confidence level. Oil and gas favorability is moderate with a moderate confidence rating as the oil industry has recently shown interest in the area and have drilled. Geothermal has a low favorability with a very low confidence level.

This WSA has more geological information, most of it recent, than most of the WSAs in the Basin and Range, however, if further study were to be done we would recommend detailed investigations of some of the more important mineral commodities in the WSA such as the borates, lithium, zeolites and gypsum.

I. INTRODUCTION

The Muddy Mountains G-E-M Resources Area (GRA No. NV-34) contains approximately 270,000 acres (1,100 sq km) and includes the following Wilderness Study Area (WSA):

WSA Name	WSA Number
Muddy Mountains	NV 050-0229

The GRA is located in Nevada within the Bureau of Land Management's (BLM) Caliente Resource Area, Las Vegas district. Figure 1 is an index map showing the location of the GRA. The area encompassed is near 36°15' north latitude, 114°45' west longitude and includes the following townships:

T 18 S, R 64-67 E
T 19 S, R 63-67 E
T 20 S, R 63-66 E

The areas of the WSA are on the following U. S. Geological Survey topographic maps:

15-minute:

Dry Lake
Hoover Dam
Muddy Peak

7.5-minute:

Frenchman Mountain
Government Wash

The nearest town is Las Vegas which is located approximately 15 miles to the west. Access to the area is via Interstate 15 to the west, State Route 40 to the north and the Lake Mead Highway to the south. Access within the area is via a few dirt roads scattered throughout the GRA and peripheral to the WSA. At least three unimproved roads penetrate the WSA.

Figure 2 outlines the boundaries of the GRA and the WSA on a topographic base at a scale of 1:250,000.

Figure 3 is a geologic map of the GRA and vicinity, also at 1:250,000. At the end of the report, following the Land Classification Maps, is a geologic time scale showing the various geologic eras, periods and epochs by name as they are used in the text, with corresponding age in years. This is so that the reader who is not familiar with geologic time subidivisions will have a comprehensive reference for the geochronology of events.

This GRA Report is one of fifty-five reports on the Geology-Energy-Minerals potential of Wilderness Study Areas in the Basin and Range province, prepared for the Bureau of Land Management by the Great Basin GEM Joint Venture.

The principals of the Venture are Arthur Baker III, G. Martin Booth III, and Dennis P. Bryan. The study is principally a literature search supplemented by information provided by claim owners, other individuals with knowledge of some areas, and both specific and general experience of the authors. Brief field verification work was conducted on approximately 25 percent of the WSAs covered by the study.

This GRA and the included WSA was field checked on December 5, 6 and 9, 1982.

One original copy of background data specifically applicable to this GEM Resource Area Report has been provided to the BLM as the GRA File. In the GRA File are items such as letters from or notes on telephone conversations with claim owners in the GRA or the WSA, plots of areas of Land Classification for Mineral Resources on maps at larger scale than those that accompany this report if such were made, original compilations of mining claim distribution, any copies of journal articles or other documents that were acquired during the research, and other notes as are deemed applicable by the authors.

As a part of the contract that resulted in this report, a background document was also written: Geological Environments of Energy and Mineral Resources. A copy of this document is included in the GRA File to this GRA report. There are some geological environments that are known to be favorable for certain kinds of mineral deposits, while other environments are known to be much less favorable. In many instances conclusions as to the favorability of areas for the accumulation of mineral resources, drawn in these GRA Reports, have been influenced by the geology of the areas, regardless of whether occurrences of valuable minerals are known to be present. This document is provided to give the reader some understanding of at least the most important aspects of geological environments that were in the minds of the authors when they wrote these reports.

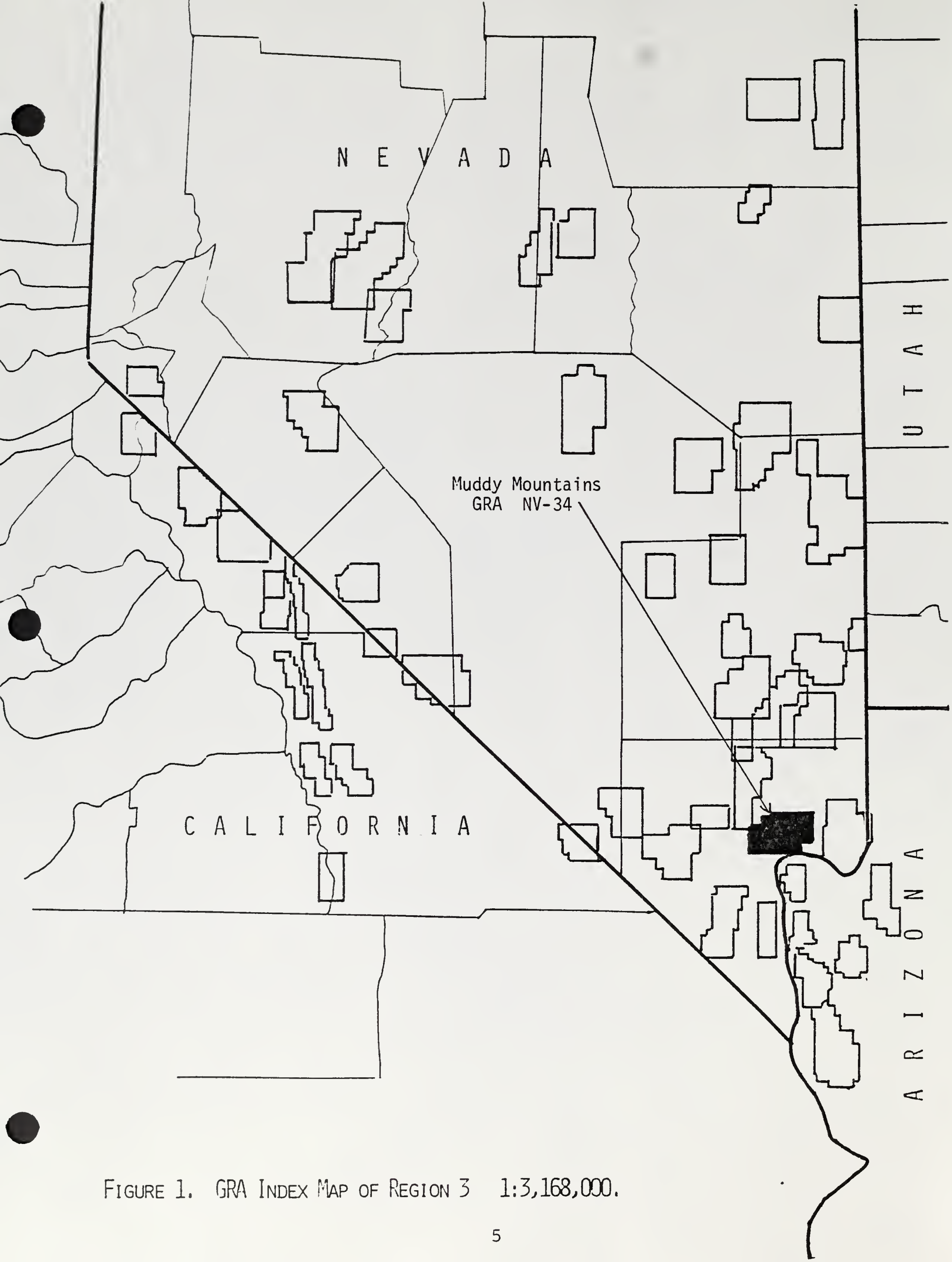
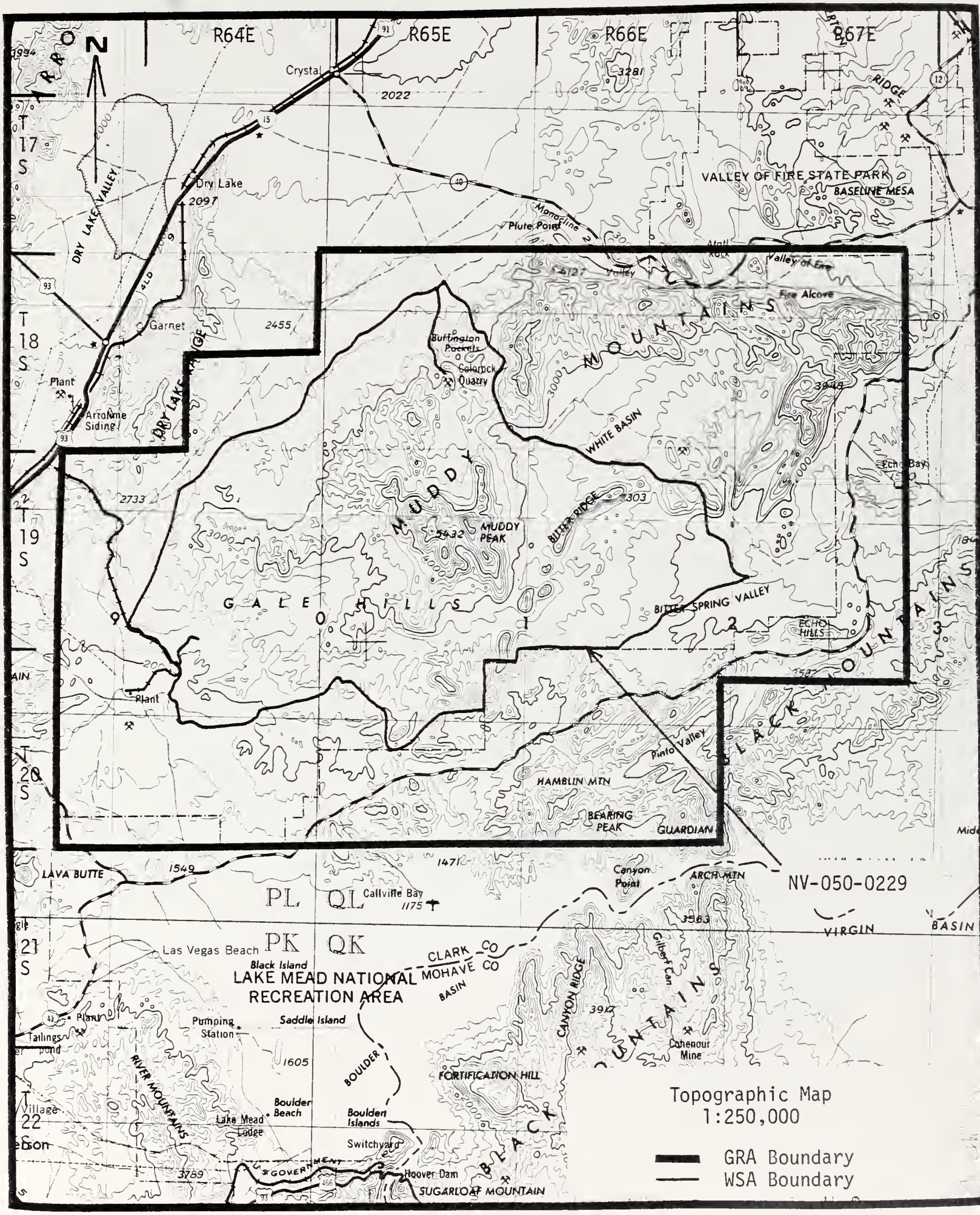


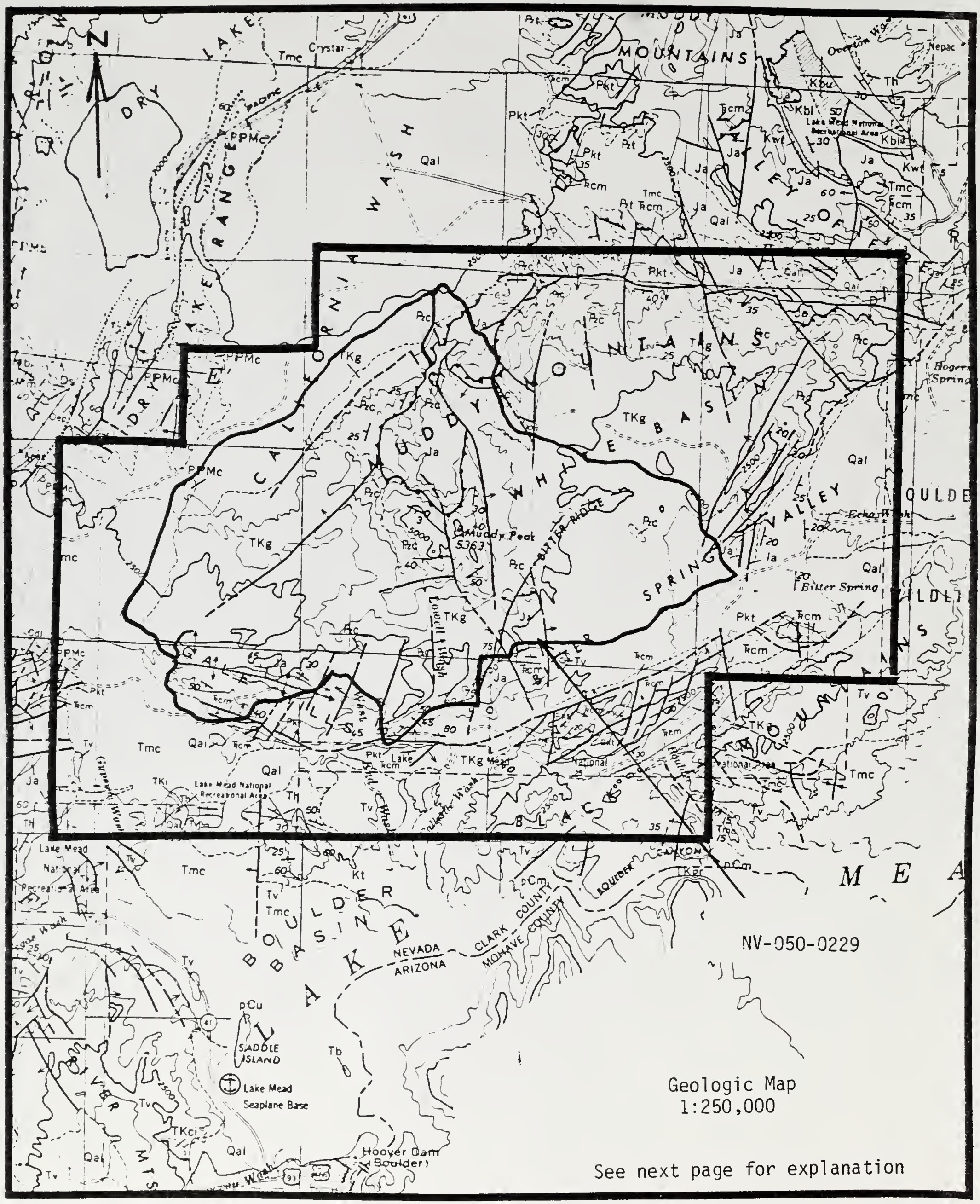
FIGURE 1. GRA INDEX MAP OF REGION 3 1:3,168,000.



Las Vegas Sheet

Muddy Mountains GRA NV-34

Figure 2



Longwell, Pampeyan, Bowyer and Roberts (1965)

Muddy Mountain GRA NV-34

Figure 3

EXPLANATION

Cenozoic Sediments

Quaternary, Undifferentiated (Qu): *Includes all sedimentary rocks and surface exposures of recent playa deposits, dune sands, lake beds, shoreline deposits and younger as well as certain older exposures of gravels and other alluvium associated with pediments and mountain streams.*

Tertiary Younger Sediments (Tys): *Sedimenetary rocks of Miocene and Pliocene age including older lake beds of the Muddy Creek Formation and Panaca Formation in Lincoln and Clark Counties; the Muddy Creek Formation in Southwestern Utah; pre-Quaternary sediments in the White River Valley; and sediments associated with ash-flow tuffs near Antelope Summit in White Pine County.*

Tertiary Sediments, Undifferentiated (Tsu): *Primarily Miocene and upper Oligocene deposits including tuffaceous sediments interbedded with ash flow tuffs, the Horse Camp Formation and various unidentified tuffs, tuffaceous shales and diatomites in Nye County; intravolcanic tuffaceous and clastic sedimentary rocks in Lincoln and Nye Counties; and conglomerates and limestones of uncertain age in the Conger-Confusion Ranges and the Cricket Mountains of Utah.*

Tertiary Older Sediments (Tos): *Includes the Sheep Pass Formation in Lincoln and Nye Counties; the Gilmore Gulch Formation in Nye County; unnamed lacustrine limestones in southern Lincoln County; older gravels, conglomerates, tuffaceous and clastic sedimentary rocks, limestones, cherts, claystones, silts, carbonaceous shales and oil shales in Elko County; and older limestones of the Illipah area and the Kinsey Canyon Formation of the Schell Creek and Grant Ranges in White Pine County.*

Cenozoic Volcanics

Quaternary Basalt (Qb): *Basalt, andesite and latite of Quaternary or late Tertiary age in Nye County.*

Tertiary Basalt (Tb): *Intermediate and basaltic lavas including the Fortification Basalt Member of the Muddy Creek Formation in Clark County; basalt flows, basaltic cinder, tuff and lava cones which are included in parts of the Banbury Formation and latite flows in Elko County; basalt flows and dikes in Lincoln County; andesite and basalt flows of various ages in North Central Nevada; and basalt and basaltic andesite flows in Southwestern Utah.*

Tertiary Volcanics, Undifferentiated (Tvu): *Early to late Tertiary volcanic rocks ranging in composition from silicic to intermediate; primarily rhyolites, dacites, quartz latite flows, ignimbrites and pyroclastics of widespread occurrence. These rocks are listed under various subdivisions in Elko, Lincoln, and Nye Counties; North Central Nevada and Southwestern Utah.*

Tertiary Older Volcanics (Tov): *Pre-Miocene volcanic rocks lithologically similar to Tertiary Volcanics, Undifferentiated (Tvu). Listed under various subdivisions in Nye County.*

Intrusives (TKJi): *Occurred from mid-Jurassic through late Tertiary. Widespread intrusions ranging in composition from granitic through gabbroic and in texture from holocrystalline to porphyritic.*

Mesozoic Sediments

Tertiary-Cretaceous Sediments (TKsu): *Continental sediments consisting of fanglomerates, clastics, tuffs and limestones. Includes the Gale Hills Formation and the Overton Fanglomerate.*

Cretaceous Sediments (Ks): *Chiefly non-marine siltstone, shale, conglomerate and limestone. Includes lower Gale Hills Formation, Thumb Formation, Baseline Sandstone, Willow Tank and Newark Canyon Formations.*

Jurassic (Ju): *Eolian cross-bedded sandstone in Utah, volcanically derived sediments, ash flows and basic lava flows in northern Elko County. Includes Navajo Sandstone, Aztec Sandstone, Frenchie Creek Formation and Bayer Ranch Formation.*

Jurassic-Triassic (JTRu): *Includes Nugget and Aztec Sandstones and Chinle Formation of southern Nevada.*

Triassic (TRu): *Shallow marine sedimentary rocks including Chinle, Shinarump, Thaynes and Moenkopi Formations in the west and continental to shallow marine sediments in the east.*

Mesozoic Volcanics

Tertiary-Cretaceous Volcanics (TKvu): *Occur in Lincoln County where it covers wide areas of the Clover, Del Mar, Wilson Creek, White Rock and Mahogany Mountains.*

Paleozoic Sediments

Permian, Undifferentiated (Pu): *Shallow marine intertidal and continental sediments. Includes Gerster Formation, Plympton Formation, Kaibab Limestone, Pequop Formation, Coconino Sandstone, Arcturus Formation, Rieptown Formation, Rib Hill Sandstone, Riepe Springs Formation, Carbon Ridge Formation and Loray Limestone. With the exception of parts of White Pine County, local symbols are used to identify all Permian outcrops. In White Pine County, local symbols are used except for the Park City Group which is grouped with the Arcturus and Rib Hill Sandstones (Par). To avoid confusion, non-standard symbol used for Permian in Utah has been replaced with the standard "P".*

Pennsylvanian-Permian (PPu): *Marine sandstone and limestone (dolomatized in places). Includes Rib Hill Sandstone, Riepe Spring Limestone and Ferguson Mountain Formation in southern Elko County; Strathearn Formation, Buckskin Mountain Formation, Beacon Flat Formation and Carlin Canyon Formation in Eureka County; Pablo Formation in Nye County; and Oquirrh Formation or group in Utah. Local symbols are used where possible.*

Pennsylvanian, Undifferentiated (Pu): *Includes Ely Limestone, Moleen and Tomera Formations. To avoid confusion, the non-standard symbol used for Pennsylvanian in Utah has been replaced by "P".*

Mississippian Upper (Mu): *Includes Diamond Peak and Bird Spring Formations, Callville Limestone, Scotty Wash Formation, Ochre Mountain Limestone and Manning Canyon Shale in parts of Clark County. Chainman Shale is combined with Diamond Peak Formation in some parts of Utah.*

Mississippian, Chainman Shale (Mc): *Includes Mountain City Formation in Elko County and Eleana Formation in Nye County.*

Mississippian, Lower (Ml): *Includes Monte Cristo and Rogers Spring Limestones in Clark County; Joana, Mercury and Bristol Pass Limestones in Lincoln County; and Joana Limestone elsewhere.*

Mississippian-Devonian, Undfiferentiated (MDu): *Includes Rogers Spring Limestone and Muddy Peak Limestone in parts of Clark County; Joana Limestone and Pilot Shale in Elko County; Pilot Shale, Joana Limestone, Chainman Shale and Diamond Peak Formation in Eureka and White Pine Counties.*

Mississippian-Devonian, Pilot Shale (MDp): *Shown in combination with other Mississippian Formations in Clark, Elko, parts of Lincoln, Eureka and White Pine Counties.*

Devonian-Cambrian, Undifferentiated (DSO€u): *Undivided limestone and dolomite occurring in Lincoln County.*

Devonian-Ordovician, Undifferentiated (DSOu): *Dolomites in Elko and Nye Counties.*

Devonian, Upper (Du): *Primarily Devils Gate and Guilmette Formations. Also includes Sevy and Simonson dolomites in parts of White Pine County. Contains Guilmette, Devils Gate, Simonson and Sevy in Elko County under the heading of* Dgd. *Local symbols used where possible.*

Simonson Dolomite (Dsi): *Alternating light to dark gray fine to coarse grained dolomite. Included with other Silurian and Devonian sediments in North Central Nevada and parts of Utah. Grouped with Sevy Dolomite in parts of Clark, Elko, Eureka, Nye, and White Pine Counties.*

Sevy Dolomite (Dse): *Very light colored, dense, distinctly bedded unfossiliferous dolomite. Combined with other Devonian and Silurian sediments in parts of North Central Nevada and Utah and with the Simonson Dolomite in parts of Clark, Elko, Eureka, Nye and White Pine Counties.*

Sevy and Simonson Dolomites, combined (Dun): *Also includes the Sultan and Muddy Peak Limestones in Clark County; Nevada Formation in Elko County; Devils Gate Formation in Eureka County; Nevada Formation, Woodpecker Limestone, Oxyolk Canyon Sandstone and Rabbit Hill Formation in Nye County; Nevada Formation and Devils Gate Formation in Eureka County and the Nevada Formation in White Pine County. Local symbols are used where possible.*

Devonian, Western Facies (Dw): *A portion of the western allochthonous assemblage. Includes Woodruff Formation and Slavern Chert in Eureka County and silicious siltstone in the Cockalorum Wash area of Nye County.*

Silurian, Undifferentiated (Su): *Includes Lone Mountain and Laketown Dolomites throughout the mapping area, the Elder Sandstone and Fourmile Canyon formation in Eureka County, and the Roberts Mountain formation in Nye County. In White Pine County, the Silurian deposits are grouped with the upper Ordovician sediments under the heading of Silurian-Ordovician, Undifferentiated (*SOu*).*

Upper Ordovician, Undifferentiated (Ouou): *Includes Ely Springs and Fish Haven Dolomites and the Hanson Creek Formation. Local symbols are used where possible. Listed as Ordovician, Undifferentiated (*Ou*) in parts of North Central Nevada. In Clark County, Ely Springs Dolomite has been divided from the rest of* Oep *by the author. The Eureka Quartzite and Pogonip Group are grouped with Silurian sediments under the heading Silurian-Ordovician, Undifferentiated (*SOu*) in Elko County.*

Ordovician, Eureka Quartzite (Oe): *Light colored vitreous quartzite and hard sandstone. Also includes the Swan Peak Quartzite in parts of Utah. In Clark County, the Eureka Quartzite has been separated from* Oep *by the author. In parts of North Central Nevada, the Eureka Quartzite has been grouped with other Ordovician sediments under the heading of* Ou*. In White Pine County, the Eureka Quartzite has been grouped with the Pogonip Group under the heading of*

Ordovician, Pogonip Group (Op): *Limestone, silty limestone, shale and interformational conglomerates. In Clark County, the Pogonip Group has been separated from* Oep *by the author. Includes the Garden City Limestone in parts of Utah. In White Pine County, the Pogonip Group is grouped the Eureka Quartzite under the heading of* Ol.

Ordovician, Undifferentiated (Ou): *Includes the Pogonip Group, Ely Springs Dolomite, Eureka Quartzite and Comus Formation in North Central Nevada.*

Ordovician, Vinini Formation (Ovi): *Part of the western allochthonous assemblage. Includes Valmi Formation in parts of North Central Nevada. Local symbols are used where possible.*

Cambrian-Ordovician, Undifferentiated (O€u): *Occurs in Elko, Eureka, Nye and White Pine Counties as shale and limestone and is usually so identified when metamorphosed to phyllite. Includes the Tennessee Mountain Formation in Elko County, Board Canyon, Sequence in North Central Nevada, Windfall Formation in Nye County and the lower Ordovician and post-Dunderberg Shale in the Schell Creek Range of White Pine County. In some parts of Nye County,* O€u *is metamorphosed to slate and marble instead of phyllite.*

Cambrian, Upper and Middle (€u): *Primarily limestones, dolomites, shales and quartzites. Includes Edgemont and Peak Limestones in Elko County; Highland Peak formation, Patterson Pass Shale, Pole Canyon Limestone, Chisholm Shale and Lyndon Limestone member of the Chisholm Shale in Lincoln County; Harmony Formation, Preble Formation, Pioche Shale, Eldorado Dolomitee, Geddes Limestone, Secret Canyon, Hamberg, Dole and Dunderberg Shales, Windfall Formation, and Scott Canyon Formation in North Central Nevada; Windfall Formation, Dunderberg Shale, Tybo Shale and Lincoln Park Formation in Nye County; Notch Peak Formation, Dunderberg Shale, Orr Formation, Weeks Formation, Marjum Formation, Wheeler Shale, Swasey Formation, Whirlwind Formation, Dome Limestone, Howell Formation and Tatow Formation in Utah; and Corset Spring Shale, Notch Peak Limestone, Dunderberg Shale and Windfall Limestone in White Pine County. Metamorphosed to schist in Elko County.*

Cambrian, Lower (€pmp): *Primarily Prospect Mountain Dolomite and Pioche Shale. Also includes Tapeats Sandstone, Wood Canyon Formation, Lyndon Limestone, Chisholm Shale and Carrera Formation in Clark County; Sterling Quartzite and Wood Canyon Formation in parts of Lincoln County; Busby Quartzite in the Gold Hill area of Utah and the Stella Lake Quartzite in White Pine County.*

Precambrian

Precambrian Sediments (p€s): *Includes the Johnnie Formation, Sterling Quartzite and some metamorphics in Clark County; Johnnie Formation and lower units of Prospect Mountain Quartzite in Lincoln County; McCoy Creek Group in Elko County; and the McCoy Creek Group excluding the Stella Lake Quartzite in White Pine County.*

Precambrian Intrusives (p€i): *Includes the Gold Butte Granite in Clark County and other undifferentiated igneous and metamorphic rocks, primarily granites and pegmatites.*

DESCRIPTION OF MAP UNITS

Qal	ALLUVIAL DEPOSITS (HOLOCENE AND PLEISTOCENE?)
Qp	PLAYA DEPOSITS (HOLOCENE AND PLEISTOCENE?)
Qc	CHEMEHUEVI FORMATION (PLEISTOCENE)
Ql	LAS VEGAS FORMATION (PLEISTOCENE)
Qm	CALICHE OF MORMON MESA (PLEISTOCENE)
Qrd	GRAVEL OF THE COLORADO AND VIRGIN RIVERS (LOWER PLEISTOCENE)
QTal	ALLUVIAL FAN DEPOSITS (QUATERNARY AND TERTIARY)
Tb	BASALT (PLIOCENE AND MIOCENE)
	MUDDY CREEK FORMATION (PLIOCENE? AND MIOCENE)
Tm	Claystone unit
Tmf	Fortification Basalt Member
Tpw	ASH-FLOW TUFF (MIOCENE)
Tp	ROCKS OF PAVITS SPRINGS (MIOCENE)
Thv	ROCKS OF THE HAMBLIN-CLEOPATRA VOLCANO (MIOCENE)
Thvi	INTRUSIVE ROCKS (MIOCENE)
Tmdv	MOUNT DAVIS VOLCANICS (MIOCENE)
	HORSE SPRING FORMATION (MIOCENE)
Ths	Sandstone and silver tuff
Thl	Rocks of Lovell Wash
Thb	Limestone of Bitter Ridge
Thl	Lower member
Tsu	UNDIFFERENTIATED SEDIMENTARY ROCKS (TERTIARY)
Kb	BASELINE SANDSTONE (UPPER AND LOWER CRETACEOUS)
Kwt	WILLOW TANK FORMATION (LOWER CRETACEOUS)
Ja	AZTEC SANDSTONE (JURASSIC)
ħmc	MOENAVE (UPPER TRIASSIC?) AND CHINLE (UPPER TRIASSIC) FORMATIONS
ħm	MOENKOPI FORMATION (MIDDLE? AND LOWER TRIASSIC)
Pkt	KAIBAB LIMESTONE AND TOROWEAP FORMATION (LOWER PERMIAN)
Pc	CLASTIC ROCKS (LOWER PERMIAN)
PIM	CALLVILLE LIMESTONE AND BIRD SPRING FORMATION (LOWER PERMIAN, PENNSYLVANIAN AND UPPER MISSISSIPPIAN)
Mm	MISSISSIPPIAN ROCKS
	DEVONIAN ROCKS
Dmp	Muddy Peak Limestone
Dms	Sultan Limestone
Sl	SILURIAN ROCKS
Ou	ORDOVICIAN ROCKS
O€u	UNDIFFERENTIATED ORDOVICIAN AND CAMBRIAN ROCKS
€dl	CARBONATE ROCKS (UPPER AND MIDDLE CAMBRIAN)
€u	UNDIFFERENTIATED CLASTIC ROCKS (MIDDLE AND LOWER CAMBRIAN)
€-Du	UNDIFFERENTIATED DEVONIAN THROUGH CAMBRIAN ROCKS
Pzu	UNDIFFERENTIATED PALEOZOIC ROCKS
p€sj	STIRLING QUARTZITE AND JOHNNIE FORMATION (PRECAMBRIAN)
p€um	ULTRAMAFIC ROCKS (PRECAMBRIAN)
p€gn	GNEISS AND SCHIST (PRECAMBRIAN)
p€rg	RAPAKIVI GRANITE (PRECAMBRIAN)

CONTACT

FAULT

THRUST FAULT

LOW-ANGLE FAULT

ANTICLINE

SYNCLINE

II. GEOLOGY

The Muddy Mountains GRA lies within the Basin and Range Province in Clark County about 12 miles northeast of Las Vegas, Nevada. The study area includes the Muddy Mountains in the north, the Black Mountains in the south and the Gale Hills in the west-central portion of the study area.

The GRA is located in the boundary zone between the Great Basin and Sonoran Desert sections of the Great Basin province and is near the eastern limit of cretaceous thrusting in the Cordilleran hingeline (Bohannon, 1982).

The GRA contains assemblages of predominantly carbonate Paleozoic marine sediments, Mesozoic carbonate and clastic sequences, Tertiary sedimentary rocks (see Figure 3).

Structures recognized in the area consist of Late Cretaceous-Early Tertiary doming, folding and thrusting, and Late Tertiary Basin and Range faults that bound individual ranges and related smaller intersecting faults.

Most of the following geological description is taken from either Longwell and others (1965) or Bohannon (1982).

1. PHYSIOGRAPHY

The Muddy Mountains GRA lies within the Basin and Range Province in Clark County about twelve miles northeast of Las Vegas, Nevada. The study area is bound on the south by Lake Mead and to the east by the Overton Arm of Lake Mead.

The GRA contains the Muddy Mountains in the north, the Black Mountains in the south and the Gale Hills in the west central portion of the study area. The included WSA covers the Gale Hills area and the southern Muddy Mountains.

Elevations are moderate, ranging from less than 2,000 feet in the valleys to 5,432 feet at Muddy Peak. The topography is rugged in the Muddy and Black Mountains with drainages predominantly emptying into Lake Mead to the south and east.

2. ROCK UNITS

The oldest rocks within the study area are Precambrian unnamed gneiss and schist in an upthrown block at Bearing Peak in the Black Mountains adjacent to Lake Mead.

The next youngest rocks are a widespread unnamed sequence of undifferentiated Paleozoic carbonate rocks which comprise a major portion of the Muddy Mountains. This rock unit has been divided into eight predominantly carbonate formations on the recently completed United States Geological Survey Geologic

Map of the Muddy Mountains Wilderness Study Area, Clark, County, Nevada (Bohannon, 1982). This map has been included in the GRA file for reference. The Kaibab limestone deposited during the Permian crops out along an east-west-trending fault in the southern half of the GRA and along the north slope of the Muddy Mountains.

Unconformably overlying the Kaibab limestone are the Triassic Moenkopi and Chinle Formations. The Moenkopi Formation consists of limestone, shale, sandstone and gypsum. The Chinle Formation is similar but does not contain limestone beds and locally has pieces of silicified wood. The Jurassic Aztec sandstone conformably overlies the Chinle Formation.

Overlying an angular unconformity is the Tertiary Gale Hills Formation (identified by Longwell and others, 1965, but no longer recognized) which is comprised of bouldery rubble, conglomerate and sandstone. This formation outcrops extensively in the Gale Hills, White Basin, and Spring Valley. Bohannan (1982) identified this rock unit as the Willow Tank Formation and Baseline Sandstone.

Miocene volcanism related to tectonic activity occurred in the Black Mountains. Thick silicic and basaltic flows mask much of the structure previously formed in that area.

Contemporaneous with the volcanics is the Horse Spring Formation which octcrops in the southwest portion of the study area. This formation, consisting of limestone, clay, sandstone, colemanite, magnesium carbonate and gypsum, was probably deposited in a shallow lake environment. Bohannon (1982) has divided and mapped this formation as to discrete members.

Bohannon (1982) has mapped small intrusive rocks of probably Muddy Creek age north of Black Mesa in western Bitter Spring Valley and in the northeastern Muddy Mountains.

The Pliocene(?) Muddy Creek Formation unconformably overlies the above mentioned volcanics and older rocks. The clastic formation is coarse-grained near the mountain borders and grades into regular beds of fine-grained sandstone, siltstone, and clay towards the basins.

3. STRUCTURAL GEOLOGY AND TECTONICS

Four groups of structural features are recognized in the study area - large intermontane faults that bound individual ranges, intersecting faults within the ranges, folding and doming, and thrust faults.

The Muddy Mountains are an irregular remnant of an overthrust block bounded by steep intermontane faults. The Muddy Mountain thrust has a well defined surface of movement between the overriding Paleozoic limestones and dolomites and the lower plate Aztec sandstone. Crumpling and minor thrust faulting indicate that the thrust force was almost directly from the west. Based on stratigraphic evidence, the Muddy Mountain thrust occurred between the Jurassic and Miocene. Structural evidence indicates that the thrusting predates the Basin and Range normal faulting. Numerous intersecting steep normal faults have cut the overthrust block creating a "mosaic" effect. Faulting in the Black Mountains is similar on the north flank where Paleozoic and Mesozoic sediments crop out. Structures in the remainder of the range are largely masked by Tertiary volcanics. The Bitter Spring Valley fault along the northwest flank of the Black Mountains has been mapped by Bohannon (1982) as having a left lateral component of movement. In the Bitter Springs Valley, the structure is broadly anticlinal on an axes trending approximately northeast.

Pronounced doming has affected the western part of the Muddy Mountains. Erosion has stripped away the thick Paleozoic overthrust sequence exposing the Aztec sandstone underneath. The Aztec forms the floor of an erosional basin where the thrust contact of the sandstone and limestone can be plainly seen in the basin walls.

An almost east-west-trending anticline plunging to the southeast is located in the Gale Hills. Several northeast trending normal faults occur to the east of the nose of the anticline.

Along the west flank of the Muddy Mountains, the California Wash fault displaces quaternary alluvium and represents the only quaternary faulting in the area (Bohannon, 1982).

4. PALEONTOLOGY

The Muddy Mountains GRA is dominated by folded and thrust faulted late Paleozoic (Pennsylvanian-Permian) and Mesozoic marine and continental sediments (Chinlee). Fossils occur throughout the area in too many locations to be listed herein. The southern equivalent of the Gabbs and Sunrise Formations locally contain ammonite dominated faunas with similarities to Alpine-Tethys facies forms. The younger units with potential for paleontological resources are the Tertiary sediments of the Horse Spring Formation.

Faunas from these formations, both inside and outside of the GRA, are given by Steele (1960), Tschanz and Pampeyan (1970), and Silberling (1956, 1959). There are at least eight fossil-bearing formations within this GRA, but seldom are fossils abundant within any one particular group. Highest number of specimens seems to occur within the Pennsylvanian-Permian strata. No definite localities given.

5. HISTORICAL GEOLOGY

During the Paleozoic a thick sequence of marine carbonates was unconformably deposited over Precambrian metamorphic rocks.

At the end of the Paleozoic, the area was uplifted and eroded. Frequent interruptions in deposition, clastic sediments mixed with thin beds of limestone, ripple marks and reptile footprints in the Moenkopi Formation indicate an emergence from marine sedimentation to a continental environment.

During the Jurassic a great desert with occasional intermittent streams stretched from southern Nevada to hundreds of miles to the east and northeast. The extensive eolian Aztec sandstone was deposited at this time.

Overthrusting related to the Laramide Orogeny and related folding initiated sometime in the Early Cretaceous. Subsequently Basin and Range faulting became active during the Early Tertiary. Thick accumulations of bouldery rubble derived from eroding newly formed tectonic highlands were deposited in the Gale Hills area.

Volcanism related to the tectonic activity was widespread in the southern portion of the study area during the early Tertiary. Contemporaneously, shallow lake chemical precipitates were deposited in some basins. Basin and Range faulting, responsible for much of the present-day topography, occurred during Miocene-Pliocene time subsequent to the volcanism. A period of erosion followed as evidenced by the angular unconformity between the Horse Spring and Muddy Creek Formations.

The Muddy Creek Formation was deposited in a similar environment as the Horse Spring but possibly with somewhat higher relief. The deformation of clay in this formation suggests that doming and faulting was locally still active during the Pliocene (Longwell, 1928).

III. ENERGY AND MINERAL RESOURCES

A. METALLIC MINERAL RESOURCES

1. Known Mineral Deposits

There are no known metallic mineral deposits within the GRA or the WSA.

2. Known Prospects, Mineral Occurrences and Mineralized Areas

Based on available information other than lithium there are no known metallic mineral prospects or occurrences within the GRA or the WSA. Although lithium is technically a metal, because it occurs in clays and is often considered an industrial mineral, it has been discussed under Nonmetallic Mineral Resources. There are numerous occurrences of manganese in the Muddy Creek Formation outside the GRA, but none has been recorded within the GRA or WSA.

3. Mining Claims

There are numerous mining claims in the GRA but all are assumed to be for nonmetallic minerals and will be discussed under that section.

Mineral leases in the southern part of the GRA in T 20 S, R 66 E are just west of the Virgin River manganese deposits and may be for that commodity. They are several miles outside the southern boundary of the WSA. The mineral leases are within the Lake Mead National Recreation Area where locating minerals is not allowed, but where locatable minerals are leasable.

4. Mineral Deposit Types

Since there are no known occurrences of metallic minerals, a discussion of deposit types is not applicable.

5. Mineral Economics

Since there are no known occurrences of metallic minerals a discussion of mineral economics is not applicable.

B. NONMETALLIC MINERAL RESOURCES

1. Known Mineral Deposits

There are seven nonmetallic mineral deposits in the GRA which have shown at least some production. They are shown on the Nonmetallics Land Classification and Mineral Occurrence Map.

The commodity presently being produced in the GRA, within a mile of the western boundary of WSA NV 050-0229 is gypsum. This is the Apex gypsum mine and mill owned by Pacific Coast Building Products, Inc. located in and around Sec. 7, T 20 S, R 64 E. This deposit is in beds of the Tertiary Muddy Creek Formation. Yearly production is in the thousands of tons (Longwell and others, 1965 and Wood, 1982).

Borate in the form of the mineral colemanite was produced in the 1920s from the Anniversary mine in Sec. 15, T 20 S, R 65 E from lenses of colemanite interbedded with clay, limestone, dolomite, and gypsum of the Horse Springs Formation (Longwell and others, 1965). Total production from this deposit was approximately 200,000 tons averaging 20 percent B_2O_3. This mine is along the southern border of the WSA (Papke, 1976).

Another similar colemanite deposit is located in Secs. 1 and 2 of T 19 S, R 66 E and was developed by the American Borax Co. Total production from this deposit was small as mining lasted only from 1922 to 1924 when litigation closed the mine. Another deposit nearby in Sec. 31 of T 18 S, R 67 E has been prospected but there has been no production. Both the above colemanite deposits are outside the northeast edge of the WSA are beds from three- to nine-feet thick and have been mined underground.

The Vanderbilt montmorillonite clay deposit in Sec. 28, T 19 S, R 64 E inside the west end of the WSA was mined between 1955 and 1975. Production comes from a six-inch to six-foot thick bed in the Horse Spring Formation. Production is reported to have varied between 100 to 200 tons per year. The mineral patent application for this deposit by Childress, 1975, further described this deposit.

Three to four carloads of silica were shipped from a quarry, the Wyatt Silica mine, in the Aztec sandstone prior to 1936 in the north part of the GRA in Sec. 12 of T 18 S, R 65 E (Longwell and others, 1965). This deposit is outside the north end of the WSA. Two miles southwest of this silica deposit and within the WSA is the Colorock Quarry which recorded minor production of building stone also from the Aztec sandstone.

A presently operating sand and gravel deposit with plant is in production just east of the Apex Gypsum mine in Sec. 8, T 20 S, R 64 E immediately adjacent to the western boundary of the WSA.

2. Known Prospects, Mineral Occurrences and Mineralized Areas

A rather large area of the Muddy Creek Formation around the above described gypsum mine along the western edge of the GRA contains additional gypsum occurrences. Other gypsum occurrences elsewhere in the GRA have also been reported by Longwell and others (1965) and are shown on the nonmetallic classification map. Bohannan mentions gypsum in both the Muddy Creek and Horse Spring Formation. The Triassic Moenkopi Formation, and the Permain Kiabab and Toroweap Formations crop out along the southern border of the GRA south of the WSA, and also contain gypsum beds.

Bentonite has been reported in the vicinity of Sec. 20, T 18 S, R 65 E. The clay bed is reported to be six to 14 feet thick lying between limestone and sandstone (Longwell and others, 1965), presumably in the Horse Spring Formation. This occurrence was not verified in the field. Several prospect pits were found just to the east during the field verification in the Horse Spring Formation in Sec. 22, however, but it is not known for what commodity they were exploring.

The Aztec sandstone crops out in a few areas in the GRA and has potential for silica and building stone production. A silica prospect in Sec. 8, T 20 S, R 65 E, has extensive outcrops of what Longwell and others (1965) believes is the Cretaceous Baseline Sandstone, the same formation that is producing silica near Overton. The Baseline Sandstone is believed to have been eroded from the Aztec Sandstone. Bohannon (1982) also agrees this is the Baseline Sandstone.

A glauberite, sodium sulfate, occurrence is reported by Longwell and others (1965) in the eastern part of T 19 S, R 66 E in the Horse Spring Formation, but the deposit has not been explored and nothing additional is known about it.

Another area of unknown prospects is found in Sec. 36, T 18 S, R 65 E. Here a limestone unit of the Horse Springs Formation has been explored by several dozer pits. Bohannan and others (1982) indicate this area has a moderate potential for borate and lithium

Zeolitization has occurred in some of the mint-green colored tuff beds in the Thumb member of the Miocene age Horse Spring Formation. These tuff beds are rarely thicker than 40 feet, but they are exposed throughout the southern and eastern parts of the WSA (Bohannon, 1982).

Results of stream-sediment sampling by Bohannon and Vine (1982), indicate that the WSA has high potential for lithium. Occurrences of hectorite, a lithium-bearing smectite clay, are found throughout the Lovell Wash member and Bitter Ridge Limestone member of the Horse Spring Formation. Because they occur in the same member of the Horse Spring Formation areas having high lithium potential have been grouped with areas having high borate potential on the Mineral Resources Potential Map of the Muddy Mountains Wilderness Study Area, Clark County, Nevada (Bohannon, and others, 1982). This map has been included in the Muddy Mountains GRA file for reference.

This same above reproduced map has locations of most mines and prospects in the WSA.

3. Mining Claims, Leases and Material Sites

Patented claims in the GRA are found at the Apex gypsum mine on the west and at the two previously described borate deposits that showed production. None of these patented claims appear to be within the designated WSA.

There are two patented claims in the WSA at the Vanderbilt clay deposit, in the vicinity of Sec. 28, T 19 S, R 64 E.

Other unpatented claim groups include:

1) Placer claims near the Apex gypsum mine in the western portion of the GRA.

2) Four to five square miles of both placer and lode claims are found in and around the Anniversary borate mine along the southern boundary of the WSA. Many of the claims appear to be within the WSA. Some of these claims were staked for lode by American Borate Company in 1980. The placers to the west cover the silica prospect and occurrences in the Baseline Sandstone.

3) A large group of lode claims was located by Duval Corporation in 1980 overlapping and to the north of the American Borax Company borate deposit in White Basin along the northeast boundary of the WSA. These claims are for borates and Duval drilled several exploration holes but have reportedly abandoned the claims as of this date (Helming, 1982).

4) Placer claims located by Intermountain Exploration in 1979 are southeast of the American Borax

deposit. It is believed these claims were located for borate or gypsum.

5) A group of claims is near the silica deposit in the Aztec sandstone in and around Sec. 12, T 18 S, R 65 E.

There are other material sites in the GRA which have shown production in the past in the same general area where the present sand and gravel operation is located near the Apex gypsum mine. They are located in Secs. 5, 8 and 15 of T 20 S, R 64 E. There are other material sites in the GRA, outside the WSA boundary, but none have shown production.

4. Mineral Deposit Types

The gypsum deposits are sedimentary evaporites.

The borates in the form of the mineral colemanite are bedded evaporite deposits, and appear to have formed by deposition of ulexite in a playa with colemanite subsequently forming by loss of sodium and water and gain of lime (Papke, 1976).

The silica and building stone in the northern part of the GRA both of which showed minor production, were mined from the Aztec Sandstone which is a widespread aeolian Jurassic sandstone. The Baseline Sandstone in the southern part of the GRA is a sedimentary sand derived from erosion of the older Aztec Sandstone.

The Vanderbilt clay occurrence is a sedimentary deposit in the Horse Spring Formation.

Zeolite, predominantly in the form of clinoptilolite, is formed by the alteration of tuffaceous material. The zeolite-bearing tuffs occur interbedded with sandstone, siltstone, limestone and claystone of the Rainbow Gardens and Thumb members of the Horse Spring Formation (Bohannon, 1982).

The Bitter Ridge Limestone and Lovell Wash members of the Horse Spring Formation are highly enriched in lithium occurring as heotorite, a lithium-bearing smectite clay. Smectite is the principal clay mineral in bentonite (Lefond, S. J., 1975) and is formed by devitrification and the accompanying chemical alteration of a glassy igneous material, usually a volcanic ash or tuff.

5. Mineral Economics

The gypsum mine and mill in the GRA obviously indicate there are gypsum beds which are economical to develop.

The borate deposits were mined in the past. There has been recent interest in these deposits by at least two major companies. Underground mining of borates has not been undertaken since 1957, when open pit mining started at the huge deposit of borax and kernite at Boron, California (Baker and Wilson, 1975).

Silica is presently being mined from deposits near Overton to the east of the GRA, however no silica is being produced from the Aztec Baseline Sandstones within the WSA.

Reconnaissance sampling for lithium in the Muddy Mountains (Bohannon and Meier, 1976; Brenner-Tourtelot and Glanzman, 1978; Brenner-Tourtelot, 1979) indicate that the Lovell Wash and upper Bitter Ridge Limestone members in the study area are highly enriched in lithium. Although some of the clays contain lithia concentrations of the same order of magnitude as commercial pegmatites, they are not likely to become lithium sources in the near future due to technological problems associated with the extraction of lithium from the crystal lattice.

Although zeolite minerals have not been mined in the WSA, technological advances have increased the number of uses for zeolite as well as the demand. Zeolite resources, calculated by Bohannon and others (1982) are about 4.7 million tons of inferred resources averaging 84 percent clinoptilolite.

By far the greatest use of gypsum is in prefabricated products, mostly wallboard, which account for nearly three-fourths of all usage. Most of the remainder is used in cement, as an agricultural soil conditioner, and in plaster. The United States consumes about 20 million tons of gypsum annually, about two-thirds of it produced domestically. Gypsum is a relatively common mineral and occurs in large deposits, and the United States has practically unlimited reserves. However, although its commonness makes it a low-priced material, some plants on the eastern seaboard use imported raw material that can be transported by ship at low cost; these account for the imports of gypsum. United States consumption is forecast to nearly double by the year 2000, with domestic production keeping up with demand except in those special situations where imported material can compete. The price for gypsum is about $7 per short ton.

A large but unknown proportion of silica or industrial sand is used in making glass, which is almost entirely silica. The second largest use is as foundry sand which is used to make molds for metal castings, and some is used as a flux in certain smelting operations. Sand is used as an abrasive in applications such as sandblasting, as a filter in various kinds of water treatment, and in a multitude of minor uses. The United States uses about 30 million tons of silica sand annually, essentially all produced domestically. Except for highly specialized sands, silica sand is a relatively low-priced material and must be produced within a few hundred miles of the point of use. Silica sand consumption in the United States is forecast to increase by about 50 percent by the year 2000. The average price for silica sand is about $10 per ton, but the price for specific sands varies widely depending on the end use and the specifications required.

Most zeolites presently being used are synthetic minerals but deposits of zeolites are known to exist and some of these are being developed and markets are being sought for them. Few details are known about the economics of zeolites so this description of their mineral economics is necessarily generalized. The United States probably uses much less than 100,000 tons of zeolites annually. Japan, where natural zeolites are used as agricultural soil conditioners and in paper, probably uses appreciably more. United States use, mostly of synthetic zeolites, is largely as catalysts in the cracking of petroleum, as molecular sieves (in which application molecules of some compounds essentially become lost in the intricate crystal structure of the zeolite, while those of other compounds pass through), and as ion exchangers. The United States has large deposits of natural zeolites, sufficient to sustain large consumption. Some advocates of zeolites foresee that the present miniscule domestic production will increase to many thousands or tens of thousands of tons in coming years, as large-scale applications are found for their unusual characteristics. There is no established price for zeolites.

About half of all boron is used in the glass industry, most of it in glass fibers for insulation or textiles, but some for specialty glasses such as Pyrex. The remainder is used in a wide variety of products such as glazes, detergents, herbicides, fluxing materials in welding, abrasives, fire retardants, and many others. The United States consumes annually about 125,000 short tons of boron, while producing nearly twice this amount. It is the largest consumer and producer of boron in the world and supplies much of the world market. United States consumption is expected to more than double by the year 2000, with production continuing to be well above consumption. The price of borax pentahydrate, the standard compound in which boron is sold, is about $175 per short ton.

C. ENERGY RESOURCES

Uranium and Thorium Resources

1. Known Mineral Deposits

There are no known uranium or thorium deposits in the WSA or GRA.

2. Known Prospects, Mineral Occurrences and Mineralized Areas

Radioactive occurrences are indicated on the Uranium Land Classification and Mineral Occurrence Map included at the back of the report.

Several occurrences of anomalous radioactivity have been noted in the southeastern portion of the GRA, near the southeastern border of the WSA, and west of the GRA near Sunrise Mountain (Garside, 1973). Seven airborne radioactive anomalies associated with a shale bed in the Horse Spring Formation were noted in Bitter Spring Valley (T 19 and 20 S, R 66 E), and anomalous radioactivity in mudstone of the Muddy Creek Formation was detected at the 50-50 claim (Sec. 15(?), T 19 S, R 67 E). The occurrence near Sunrise Mountain consists of airborne radioactive anomalies near granite which may cut Tertiary lake deposits in the vicinity of Gypsum Cave (Secs. 10, 12, 14, T 20 S, R 63 E).

3. Mining Claims, Leases and Material Sites

There are no known uranium or thorium claims or leases in the WSA or GRA.

4. Mineral Deposit Types

This section is inapplicable, as there are no uranium or thorium deposits in the WSA or GRA.

5. Mineral Economics

Uranium and thorium appear to be of little economic value in the WSA or GRA due to the lack of known deposits in the area.

Uranium in its enriched form is used primarily as fuel for nuclear reactors, with lesser amounts being used in the manufacture of atomic weapons and materials which are used for medical radiation treatments. Annual western world production of uranium concentrates totaled approximately 57,000 tons in 1981, and the United States was responsible for about 30 percent of this total, making the United States the largest single producer or uranium (American Bureau of Metal Statistics, 1982). The United States ranks second behind Australia in uranium resources based on a production cost of $25/pound or less. United States uranium demand is growing at a much slower rate than was forecast in the late 1970s, because the number of new reactors scheduled for construction has declined sharply since the accident at the Three Mile Island Nuclear Plant in March, 1979. Current and future supplies were seen to exceed future demand by a significant margin and spot prices of uranium fell from $40/pound to $25/pound from January, 1980 to January, 1981 (Mining Journal, July 24, 1981). At present the outlook for the United States uranium industry is bleak. Low prices and overproduction in the industry have resulted in the closures of numerous uranium mines and mills and reduced production at properties which have remained in operation. The price of uranium at the end of 1982 was $19.75/pound.

Oil and Gas Resources

1. Known Oil and Gas Deposits

There are no known oil and gas deposits within the GRA.

2. Known Prospects, Oil and Gas Occurrences and Petroliferous Areas

There are no known oil seeps or reported oil or gas shows in wells drilled within the WSA or GRA. Chevron/Halbouty was drilling the Colorock Quarry No. 1 (#1 on the Oil and Gas Occurrence and Land Classification Map) to a projected 9,000-foot depth in 1983. By the second quarter of 1983, the Nevada Department of Conservation and Natural Resources (Nevada Division of Mineral Resources, personal communication, 1983) did not know the disposition of the well, though it was not abandoned. Less than one mile outside the WSA, but within the GRA, Shell Oil Company drilled the Bowl of Fire No. 1 (#2) to 5,919 feet in 1959, and the Rosan Oil Company Muddy Dome (Fed) No. 1 (#3) bottomed at 5,666 feet in 1965. Both these wells had slight oil shows in the Upper Paleozoics (Nevada Bureau of Mines and Geology Oil and Gas Files, 1982, Schilling and Garside, 1968). The Chevron Buffington Pocket No. 1 (#4) on the edge of the WSA, is a proposed location (Nevada Division of Mineral Resources Oil and Gas Files, 1982).

Five additional wells to the north of the GRA were drilled during the 1940s and 1950s. One of these, the Southern Great Basin well (#5), encountered oil shows (Nevada Bureau of Mines and Geology Oil & Gas Files, 1982). During the later part of 1982 Grace Petroleum Co. (#6) was drilling at about 17,000 feet as part of the Overthrust Belt exploration by industry. No information is available on this well.

3. Oil and Gas Leases

Federal oil and gas leases cover the entire GRA.

4. Oil and Gas Deposit Types

Oil deposits that have been found and developed, and those that are being explored for in the Basin and Range to date, have been limited to the Upper Paleozoic section of the miogeosyncline and the Tertiary section of the intermontane basins. The source rocks are assumed to be in Paleozoic horizons, such as the Mississippian Chainman Shale, and perhaps also the Tertiary section.

The reservoirs at the Trap Spring and Eagle Springs oil fields in Railroad Valley are the Oligocene Garrett Ranch volcanics or equivalent, which produce from fracture porosity; or the Eocene Sheep Pass Formation, a freshwater limestone. Minor production has been recorded from the Ely(?) Formation of Pennsylvanian age at Eagle Springs. It may be that production also comes from other units in the Tertiary or Paleozoic sections in the Blackbrun oil field in Pine Valley or the Currant and Bacon Flat oil fields in Railroad Valley.

The GRA is within or close to the North American Overthrust Belt which has good oil and gas production in Wyoming/Utah, Mexico and Canada (Oil and Gas Jour., May 12, 1980). The Federal leases in Nevada are for rank wildcat acreage, and surficial stratigraphic units do not necessarily have a direct bearing on possible drilling objectives at depth, considering overthrust structural implications.

Recent seismic surveys (e.g., Seisdata Services, 1981; Geophysical Service Inc., 1981; GeoData, 1981: Index maps in GRA File) indicate, in part, the general area of industry interest. This and certain other data may be purchased, but deep exploratory test data are not readily available. Published maps of the Overthrust Belt in Nevada are very generalized, and are not necessarily in agreement because exploration is at an early stage (Oil and Gas Jour., May 12, 1980; Western Oil Reporter, June, 1980; Keith, 1979: Index maps in GRA File).

5. Oil and Gas Eonomics

The low level of production from Nevada Basin and Range oil fields, which are remote from existing pipelines, existing refineries and consuming areas, necessitates the trucking of the crude oil to existing refineries in Utah, California and Nevada. Since the discovery of oil in Nevada in 1953, the level of production has fluctuated. Factors which have affected the production from individual wells are: reservoir and oil characteristics; Federal regulations; productivity; environmental constraints; willingness or ability of a refiner to take certain types of oil; and of course, the price to the producer, which is tied to regional, national and international prices.

Geothermal Resources

1. Known Geothermal Deposits

There are no known geothermal deposits in the GRA.

2. Known Prospects, Geothermal Occurrences and Geothermal Areas.

No known prospects, occurrences or thermal areas occur in the GRA, but a mile east of the GRA boundary (Locality #1) at the Rogers Spring area, Rogers Spring is recorded as being warm and Blue Point Spring flows 82°F water. Three miles south of the GRA near Lake Mead, the National Park Service Camp ground well at Callville Bay is 84°F at 200 feet. Further south near Hoover Dam are a series of thermal springs in Back Canyon which measure 78°to 145°F (Garside and Schilling, 1979).

3. Geothermal Leases

There are no Federal geothermal leases in the GRA or immediate region.

4. Geothermal Deposit Types

Geothermal resources are hot water and/or steam which occurs in subsurface reservoirs or at the surface as springs. The temperature of a resource may be about 70°F (or just above average ambient air temperature) to well above 400°F in the Basin and Range province.

The reservoirs may be individual faults, intricate fault-fracture systems, or rock units having intergranular permeability -- or a combination of these. Deep-seated normal faults are believed to be the main conduits for the thermal waters rising from thousands of feet below in the earth's crust.

The higher temperature and larger capacity resources in the Basin and Range are generally hydrothermal convective systems. The lower temperature reservoirs may be individual faults bearing thermal water or lower pressured, permeable rock units fed by faults or fault systems. Reservoirs are present fom the surface to over 10,000 feet in depth.

5. Geothermal Economics

Geothermal resources are utilized in the form of hot water or steam normally captured by means of drilling wells to a depth of a few feet to over 10,000 feet in depth. The fluid temperature, sustained flow rate and water chemistry characteristics of a geothermal reservoir determine the depth to which it will be economically feasible to drill and develop each site.

Higher temperature resources (above 350°F) are currently being used to generate electrical power in Utah and California, and in a number of foreign countries. As fuel costs rise and technology improves, the lower temperature limit for power will decrease appreciably -- especially for remote sites.

All thermal waters can be beneficially used in some way, including fish farming (68°F), warm water for year-round mining in cold climates (86°F), residential space heating (122°F), greenhouses by space heating (176°F), drying of vegetables (212°F), extraction of salts by evaporation and crystallization (266°F), and drying of diatomaceous earth (338°F).

Unlike most mineral commodities remoteness of resource location is not a drawback. Domestic and commercial use of natural thermal springs and shallow wells in the Basin and Range province is an historical fact for over 100 years.

Development and maintenance of a resource for beneficial use may mean no dollars or hundreds of millions of dollars, depending on the resource characteristics, the end use and the intensity or level of use.

D. OTHER GEOLOGICAL RESOURCES

There is a cave along the very western boundary of the GRA known as Gypsum Cave which has been mined for gypsum in the past. This cave is outside the WSA boundary immediately west of the Apex gypsum mine and mill.

Buffington Pockets along the northern portion of the WSA and the Bowl of Fire in the south are both unusual erosional area of the Aztec sandstone similar to the erosional shapes in the Valley of Fire State Park in the northeast corner of the GRA outside the WSA boundary.

In the Anniversary mine area along the southern border of the WSA there is interest in "rock hounding" for agates and other minerals.

E. STRATEGIC AND CRITICAL MINERALS AND METALS

A list of strategic and critical minerals and metals provided by the BLM was used as a guideline for the discussion of strategic and critical materials in this report.

The Stockpile Report to the Congress, October 1981-March 1982, states that the term "strategic and critical materials" refers to materials that would be needed to supply the industrial, military and essential civilian needs of the United States during a national emergency and are not found or produced in the United States in sufficient quantities to meet such need. The report does not define a distinction between strategic and critical minerals.

There are no strategic and critical minerals known to exist in the GRA.

IV. LAND CLASSIFICATION FOR G-E-M RESOURCES

This WSA has been studied in great detail by Bohannon (1982), Bohannon and Vine (1982) and Bohannon and others (1982). This was a study undertaken by the USGS for the Bureau of Land Management specifically for the evaluation of this WSA. The entire WSA was mapped in detail at a scale of 1:62,500, a geochemical stream-sediment and whole-rock sampling program was undertaken on 235 samples, and the WSA was rated for its mineral resource potential. These publications became available to the authors of this GRA Report after the draft report was already completed. This final report incorporates this work done by the USGS and the above three references are considered an indispensible addition to the evaluation of the Muddy Mountains Wilderness Study mineral potential. These publications are included in the GRA file for this WSA. Overall the quantity and quality of the geologic data is very good and the confidence level is high. The information on mineral resources is very good and its confidence level is also high. The information on mineral resources is not totally comprehensive though in that each known mineral deposit has not been mapped in detail.

The geologic map used in this report is lacking in detail, is at a scale of 1:250,000, and comes from the Clark County Geologic report by Longwell and others (1965). The mineral classification maps are simplified and more detailed analysis of boundaries and potential should be in conjunction with Bohannon's (1982) map and Bohannon and others (1982) Mineral Potential Map.

Land classification areas are numbered starting with the number 1 in each category of resources. Metallic mineral land classification areas have the prefix M, e.g., M1-4D. Uranium and thorium areas have the prefix U. Nonmetallic mineral areas have the prefix N. Oil and gas areas have the prefix OG. Geothermal areas have the prefix G. Sodium and potassium areas have the prefix S. The saleable resources are classified under the nonmetallic mineral resource section. Both the Classification Scheme, numbers 1 through 4, and the Level of Confidence Scheme, letters A, B, C, and D, as supplied by the BLM are included as attachments to this report. These schemes were used as strict guidelines in developing the mineral classification areas used in this report.

Land classifications have been made here only for the areas that encompass segments of the WSA. Where data outside the WSA has been used in establishing a classification area within the WSA, then at least a part of the surrounding area may also be included for clarification. The classified areas are shown on the 1:250,000 mylars or the prints of those that accompany each copy of this report.

In connection with nonmetallic mineral classification, it should be noted that in all instances areas mapped as alluvium are classified as having moderate favorability for sand and gravel.

All areas mapped as principally limestone or dolomite have a similar classification since these rocks are usable for cement or lime production. All areas mapped as other rock, if they do not have specific reason for a different classification, are classified as having low favorability, with low confidence, for nonmetallic mineral potential, since any mineral material can at least be used in construction applications.

1. LOCATABLE RESOURCES

a. Metallic Minerals

WSA NV 050-0229

M1-2B. This classification area of low favorability for manganese with a low confidence level includes the Muddy Creek Formation along the western boundary of the WSA. This area also includes the alluvium along the northwestern edge of the WSA, under which the Muddy Creek Formation is presumed to be present. It has a low potential for manganese. Even though there has been no reported manganese occurrences at this location, the Muddy Creek Formation to the south of the GRA contains the Virgin River Manganese deposits described by Longwell and others, 1965. Additional manganese is found in the Muddy Creek several miles to the southwest of the GRA at the Three Kids deposit near Henderson. There would possibly be manganese at depth in this formation so this classification refers to a subsurface potential only. The boundary of this classification area is approximate and is based on mapping of the unit by Bohannon (1982).

M2-1B. This classification area does not indicate a favorability for metallic resources with a low confidence level and includes the entire WSA for all remaining metallic mineral resources. There are no metallic occurrences known (other than lithium which is addressed in the nonmetallics section as it is closely associated with the borates in the WSA). Bohannon and others (1982) recognized little potential for metallic mineral resources (other than lithium) in the WSA. Their extensive geochemical sampling program indicated no significant anomalies of metals within the WSA. Bohannon did say, however, that a definitive statement regarding subsurface potential cannot be made. He also stated:

> "Although the WSA is in a similar terrane to that in the nearby Goodsprings mining district, the lack of intermediate to silicic volcanic and intrusive rocks in the WSA, that are present in the mining district, it is considered unlikely that large subsurface deposits like those at Goodsprings exist in the WSA."

b. Uranium and Thorium

WSA NV 050-0229

U1-1A. This land classification covers two areas in the central part of WSA NV 050-0229, two small areas west of the WSA in the GRA and part of the northwest corner of the GRA. The area is covered by Paleozoic carbonates and the Jurassic Aztec sandstone, and appears to have very little uranium favorability with a very low confidence level due to a lack of known uranium source rocks such as silicic volcanics.

The area has very low favorability for thorium, with a very low level of confidence due to an apparent lack of source rocks such as pegmatites.

U2-2B. This land classification covers two areas in the GRA which are southeast of the WSA. These areas are covered by the Triassic Moenkopi and Chinle Formations, Permian Kaibab limestone, Jurassic Aztec sandstone, and Tertiary volcanics. The area has low favorability with a low confidence level for uranium as fracture-fillings or veins in the volcanics or epigenetic sandstone-type deposits in the Mesozoic sedimentary rocks. The volcanics in the southern part of the area are a possible source of uranium, which could be leached by ground water and deposited in fractures in volcanics or sedimentary rocks or reduced zones in sandstones.

The area has very low favorability with a very low level of confidence for thorium due to the apparent lack of source rocks such as pegmatites.

U3-2B. This land classification covers the western and eastern portions of the WSA, and portions of the GRA which are covered by the Tertiary, Horse Springs Formation and Muddy Creek Formation. The area has low favorability with a low confidence level for epigenetic sandstone-type uranium deposits in these formations. Tuffaceous units within these formations may provide a source for uranium which can be leached and redeposited by ground water where it encounters reducing zones in the sediments. The occurrences of anomalous radioactivity in the Horse Springs and Muddy Creek Formations near the southeastern margin of the WSA, indicate that these units may be potential host or source rocks for sandstone-type uranium deposits.

The area has very low favorability with very low confidence for thorium due to the apparent lack of source rocks such as pegmatites.

c. Nonmetallic Minerals

WSA NV 050-0229

N1-4D. This classification area of high favorability with a high confidence level includes the Muddy Creek Formation around the Apex gypsum mine near the western border of the WSA. This area is presently being mined. There is a mill at the site and there are abundant mining claims.

N2-4D. This classification area of high favorability with a high confidence level is the Vanderbilt montmorillionite clay deposit. Several thousand tons have been reported mined here and there are presently stockpiles of Montmorillonite on the property. This deposit was field verified during this study. The outline of this classification area is approximate and corresponds with Bohannon and other (1982) area H on their mineral resource potential map. This area corresponds to known areas of the clay at the surface.

N3-4D. This classification area of high favorability with a high confidence level includes the American borax mine outside the northeast edge of the WSA where borates have been produced in the past. Bohannon and others (1982) indicates the mine is in a claystone, limestone and tuff sequence of the Lovell Wash member of the Horse Spring Formation.

N4-4D. This classification area of high favorability with a high confidence level includes the Anniversary mine which is a past borate producer on the southern edge of the WSA. Bohannon and others (1982) indicates the mine is in the Bitter Ridge Limestone and Lovell Wash members of the Horse Spring Formation. This area has been rated as having a moderate potential for silica sand by Bohannon and others (1982).

N5-3C. This classification area of moderate favorability and moderate confidence level includes all the outcrops of Aztec sandstone in the WSA. This material has potential for use both as a building stone and as a source of silica sand. These areas are found near the middle northern portion of the WSA and in the southeastern portion of the WSA. Bohannon and others (1982) indicates these areas have a low to moderate potential for silica sand and building stone.

N6-3C. This classification area of moderate favorability with a moderate confidence level includes the Baseline Sandstone, the only outcrops of which are found along the southern boundary of the WSA. A field check of this site in December 1982 revealed extensive prospecting has taken place in Sec. 8, T 20 S, R 65 E (Bohannon and others (1982) on their map does not indicate any activity here).

Most of these workings are on the west side of West End Wash and, therefore, just outside the WSA boundary. The reason for the 3C classification is that prospecting has occurred and some of this material is very similar to that Baseline Sandstone which is presently being mined approximately 25 miles to the northeast near Overton.

N7-3C. This classification area of moderate favorability with a moderate confidence level includes all the Paleozoic and Mesozoic carbonate sedimentary rocks in the WSA. These materials could possibly be utilized in cement or lime manufacture. Bohannon and others (1982) did not rate these rocks as having potential. Only the major outcrops of these units are shown on the Land Classification Map for clarity, but all areas mapped as limestone on Bohannon's map should be considered as being this classification.

N8-3C. This classification area of moderate favorability with a moderate confidence level includes all the alluvium mapped in the WSA. Here again the Land Classification Map has been simplified for clarity and all areas of alluvium mapped by Bohannon should be considered as a part of this classification. There is one operating sand and gravel pit in a wash at the very southwest corner of the WSA. Many of the washes within the WSA may be similar in that clean sand and gravel could be produced from them. The 3C classification is because each individual site would have to be evaluated for physical properties. A small portion of the wash upstream from where the current sand and gravel pit is operating and within the WSA could be considered as 4D. Bohannon and others (1982) did not classify any of the alluvium in the WSA as having potential for sand and gravel.

N9-3C. This classification area of moderate favorability with a moderate confidence level includes all those areas in the WSA which Bohannon and others (1982) indicates have a high potential for borate and lithium. This classification area surrounds the Anniversary mine on the southern border of the WSA and the southwestern extension of the Horse Spring Formation at the American borax mine. This classification area is confined to the Horse Spring Formation. For more detail refer to Bohannon and others' (1982) map.

N10-3C. This classification area of moderate favorability with a moderate confidence level includes all the areas in the WSA which Bohannon and others (1982) indicates has a moderate potential for zeolite minerals.

N11-3C. This classification area of moderate favorability with a moderate confidence level includes all the remaining areas of the WSA not previously classified. Bohannon does not indicate a favorability for any mineral commodity in these areas. This area is underlain by several different units (see Bohannon, 1982, for detail) including:

1. Horse Spring Formation -- potential nonmetallic resources include limestone, gypsum, clays and sandstone.

2. Alluvium -- potential source of sand and gravel

3. Muddy Creek Formation -- potential nonmetallic resources include gypsum and clay

4. Red sandstone unit -- potential nonmetallic resources include sandstone, gypsum

Of the potential commodities listed above gypsum is probably the one of most importance. There is an operating gypsum mine just outside the western edge of the WSA and Longwell and others (1965) has reported gypsum inside the WSA. In addition, he reports a glauberite occurrence in the eastern portion of the WSA. Opalized chalcedony and agates are also reportedly found at various locations.

2. LEASABLE RESOURCES

a. Oil and Gas

WSA NV 050-0411

OG1-3C. There are two wells (#2 and #3) that have drilled a good Paleozoic section (at least Ordovician through Permian) with potential source and reservoir sections. Oil shows were found in both wells, each drilled at opposite ends of an overthrust anticline (Nevada Bureau of Mines and Geology Oil and Gas Files, 1982). Chevron/Halbouty's well (#1), according to the Chevron office in Concord, California (personal communication, 1982), is being drilled to test Overthrust Belt objectives. They expect to be drilling and testing at this or nearby sites for several years.

The WSA is entirely covered by Federal leases which are believed to be within the Overthrust Belt.

The fact that there are hydrocarbon shows in three wells bordering the WSA is direct evidence to the presence of the mineral occurrence, but the shows are minimal.

b. Geothermal

WSA NV 050-0229

Gl-2A. The WSA is largely underlain by the intricately faulted Muddy Mountains. The geologic map also indicates that much of this faulting is Cenozoic in age, and extends to areas covered by Quaternary alluvium. The thermal springs noted in Section III (c) Geothermal are all believed to be genetically related to this tectonism. It is understood that thermal water will rise along permeable portions of some of these faults and come to the surface as springs; and in some cases such as at Callville Bay (#2), shallow wells will intersect these warm waters in near-surface strata. Similar favorable sites for low-temperature geothermal resources may be present in the WSA.

c. Sodium and Potassium

Sl-2B. This classification is of low favorability with a low confidence level. Sodium sulfate, in the form of glauberite, is found as an occurrence in the WSA and is included in the discussion above under nonmetallic mineral resources classification.

3. SALEABLE RESOURCES

The saleable resources, sand and gravel, are included in the discussion of nonmetallics above.

V. RECOMMENDATIONS FOR ADDITIONAL WORK

The entire GRA and the included WSA is a prime area of interest for nonmetallic mineral resources. This WSA has been thoroughly investigated by the USGS (Bohannon) and classified as to its mineral potential. The level of detailed work for this WSA far exceeds any other WSA involved in this study of the Basin and Range. Further recommendations to assist in evaluation of mineral potential would include even more detailed mapping and sampling of some of the mineral commodities such as borate, lithium, zeolites, gypsum and clay.

VI. REFERENCES AND SELECTED BIBLIOGRAPHY

American Bureau of Metal Statistics Inc., 1982, Non-ferrous metal data - 1981, Port City Press, New York, New York, p 133-134.

Armstrong, R. L., 1963, Geochronology and geology of the eastern Great Basin in Nevada and Utah: Ph.D. thesis, Yale University, New Haven, Conn.

Baker, J. M., and Wilson, J. L., 1975, Borate deposits in the Death Valley region in Guidebook: Las Vegas to Death Valley and Return: Nevada Bur. of Mines and Geol. Report 26.

Brenner-Tourtelot, E. F., 1978, Geologic map of the lithium-bearing rocks in parts of the Frenshman Mountain and Henderson quandrangles, Clark County, Nevada: U. S. Geol. Survey Misc. Field Studies Map MF-1079, scale 1:24,000.

Brenner-Tourtelot, E. F., and Glanzman, R. K., 1978, Lithium-bearing rocks of the Horse Spring Formation, Clark County, Nevada: Energy (Pergamon Press), v. 3, no. 3, p. 255-262.

Bohannon, R. G., 1977, Preliminary geologic map and sections of White Basin and Bitter Spring Valley, Muddy Mountains, Clark County, Nevada: U. S. Geol. Survey Misc. Field Studies, Map MF-922.

Bohannon, R. G., 1982, Geologic map of the Muddy Mountains wilderness study area, Clark County, Nevada: U. S. Geol. Survey Misc. Field Studies Map MF-1458-A Scale 1:62,500.

Bohannon, R. G., and Meier, a. L., 1976, Lithium in sediments and rocks in Nevada: U. S. Geol. Survey Open-File Report 76-567.

Bohannon, R. G., and Vine, J. D., 1982, Geochemical map of the Muddy Mountains wilderness study area, Clark County, Nevada: U. S. Geol. Survey Misc. Field Studies Map MF-1458-B. Scale 1:62,500.

Bohannon, R. G., Leszcyowski, A. M., Esparaza, L. E., and Rumsey, C. M., 1982, Mineral resources potential map of the Muddy Mountains wilderness study area, Clark County, Nevada: U. S. Geol. Survey Misc. Field Studies Map MF-1458-C Scale 1:62,500.

Childress, L. B., 1975, USBLM Mineral Patent Application for R. T. Vanderbilt Co., T 19 S, R 64 E, Nevada.

Cook, Thomas, 1982, BLM Geologist, Personal communication with Dennis Bryan, December 1982.

Elevatorski, E. A., mgr., 1973, Nevada Industrial Minerals: Minobrass, 62 p.

Fulton, J. A., and Smith, A. M., 1932, Nonmetallic minerals in Nevada: Nevada Univ. Bull., v. 26, no. 7, Nev. Bur. Mines and Mackay School of Mines Bull. no. 17.

Gale, H. S., 1921, The Callville Wash colemanite deposit (Clark County, Nevada): Eng. Mining Jour., v. 112, no. 13, p. 524-530.

Garside, L. J., and Schilling, J. H., 1979, Thermal waters of Nevada: Nevada Bur. of Mines and Geol. Bull. 91.

Garside, L. J., 1973, Radioactive mineral occurrences in Nevada: Nevada Bur. Mines Bull. 81, 121 p.

Geodata, 1981, Eastern Nevada multifold seismic data available: Geodata Corp., Denver, Colorado.

Geophysical Service Inc., 1981, southeastern Nevada hingeline: Non-exclusive seismic surveys available.

Gilbert, G. K., 1875, Report on the geology of portions of Nevada, Utah California, and Arizona: U.S. Geog. and Geol. Surveys W. 110th Meridian Rept. (Wheeler), v. 3, p. 17-187.

Hale, F. A., Jr., 1918, Manganese deposits of Clark County, Nevada: Eng. Mining Jour., v. 105, p. 775-777.

Helming, Bob, 1982, Senior geologist with Duval Mining Co., Personal communication with Diana Pocapalia, December 13, 1982.

Hill, J. M., 1916, Notes on some mining districts in eastern Nevada: U.S. Geol. Survey Bull. 648.

Jaster, M. C., 1956, Perlite resources of the United States: U.S. Geol. Survey Bull. 1027-I, p. 375-402.

Keith, S. B., 1979, The great southwestern Arizona overthrust oil and gas play: Arizona Bur. of Geol. and Min. Tech., March.

Langenheim, R. L., 1956, Lower Mississippi stratigraphic units in southern Nevada (abs.): Geol. Soc. America Bull., v. 67, no. 12, p. 1773.

Langenheim, R. L., Jr., and Larson, E. R., 1973, Correlation of Great Basin stratigraphic units: Nevada Bur. Mines and Geol., Bull. 72, p. 1-36.

Lefond, S. J., Editor-in-chief, 1975, Industrial minerals and rocks: 4th edition. Seely W. Mudd Series, Society of Mining Engineers.

Longwell, C. R., 1921, Geology of the Muddy Mountains, Nevada, with a section to the Grand Wash Cliffs in western Arizona: Am. Jour. Sci., 5th ser., v. I, p. 39-62.

-----,1922, Muddy Mountain overthrust in southeastern Nevada: Jour. Geology, v. 30, p. 63-72.

-----, 1928, Geology of the Muddy Mountains, Nevada with a section through the Virgin Range to the Grand Wash Cliffs, Arizona: U. S. Geol. Survey Bull. 798.

-----, 1945, Low-angle normal faults in the Basin and Range province: Am. Geophys. Union Trans., v. 26, pt. I, p. 107-118.

-----, 1949, Structure of the northern Muddy Mountain area, Nevada: Geol. Soc. America Bull., v. 60, p. 923-967.

-----, 1952, Structure of the Muddy Mountains, Nevada, in Thune, H. W., ed., Cedar City, Utah, to Las Vegas, Nevada: Utah Geol. Soc.: Guidebook to the Geology of Utah, no. 7, p. 109-114.

-----, 1960, Possible explanation of diverse structural patterns in southern Nevada: Am. Jour. Sci., v. 258-A, p. 192-203.

-----, 1963, Reconnaissance geology between Lake Mead and Davis Dam, Arizona-Nevada: U.S. Geol. Survey Prof. Paper 374-E.

Longwell, C. R., Pampeyan, E. H., Bowyer, B., and Roberts, R. J., 1965, Geology and mineral deposits of Clark County, Nevada: Nevada Bureau of Mines Bulletin 62.

McKee, E. D., 1938, The environment and history of the Toroweap and Kaibab Formations of northern Arizona and southern Utah: Carnegie Inst. Washington Pub. 492.

McKelvey, V. E., Wiese, J. H., and Johnson, V. H., 1949, Preliminary report on the bedded manganese of Lake Mead region, Nevada and Arizona: U. S. Geol. Survey Bull. 948-D.

Mining Journal, July 24, 1982, vol. 297, No. 7641.

Murphy, T. D., 1954, Silica resources of Clark County, Nevada: Nevada Bur. Mines Bull. 55.

-----, 1922, Colemanite in Clark County, Nevada: U. S. Geol. Survey Bull. 735-B, p. 23-39.

Nevada Bureau of Mines and Geology Oil and Gas Files, 1982.

Nevada Division of Mineral Resources Oil and Gas Files, 1982.

Nolan, T. B., 1943, The Basin and Range Province in Utah, Nevada and California: U. S. Geol. Survey Prof. Paper 197D, p. 141-146.

Oil and Gas Jour., May 12, 1980, What's been found in the North American Overthrust Belt.

Papke, K. G., 1970, Montmorillonite, bentonite and fullers earth deposits in Nevada: Nevada Bur. of Mines and Geol. Bull. 76.

Papke, K. G., 1976, Evaporites and brines in Nevada playas: Nevada Bur. of Mines and Geol. Bull. 87.

Papke, K. G., 1982, Personal communcations with Dennis Bryan, November, 1982.

Schilling, J. H. and Garside, L. J., 1968, Oil and gas developments in Nevada 1953-1967: Nevada Bur. Mines and Geol. Rept. 18.

Seisdata Services, 1981, Seismic data available in southern Nevada.

Silberling, N. J., 1956, Trachyeres zone in the upper Triassic of the western United States: Jour. Paleo. v. 30, p. 1147-1153.

_____, 1959, Pre-Tertiary stratigraphy and upper Traissic paleontology of the Union District, Shoshone Mountains, Nevada: U. S. Geol. Survey Prof. Paper 322, 67 p.

Spurr, J. E., 1903, Descriptive geology of Nevada south of the fortieth parallel and adjacent portions of California: U. S. Geol. Survey Bull. 208.

Steele, G., 1960, Pennsylvanian-Permian stratigraphy of east-central Nevada and adjacent Utah, in geology of east-central Nevada: Intermountain Assox. Petroleum Geologists and Eastern Nevada Geol. Sox., 11th Ann. Field Conf., Salt Lake City, Utah.

Stewart, J. H., and Carlson, J. E., 1978, Geologic map of Nevada: U. S. Geol. Survey in cooperation with Nevada Bur. of Mines and Geology.

Stewart, J. H., 1980, Geology of Nevada - a discussion to accompany the geologic map of Nevada: Nevada Bureau of Mines and Geol. Spec. Publ., no. 4, p. 1-136.

Tschanz, C. M., and Pampeyan, E. H., 1970, Geology and mineral deposits of Lincoln County, Nevada: Nevada Bur. Mines Bull. 73, p. 1-187.

Vanderburg, W. O., 1937, Reconnaissance of mining districts in Clark County, Nevada: U.S. Bur. Mines Inf. Circ. 6964.

Webb, G. W., Middle Ordovician stratigraphy in eastern Nevada and western Utah: American Assoc. Petroleum Geologists Bull., v. 42, p. 503-522.

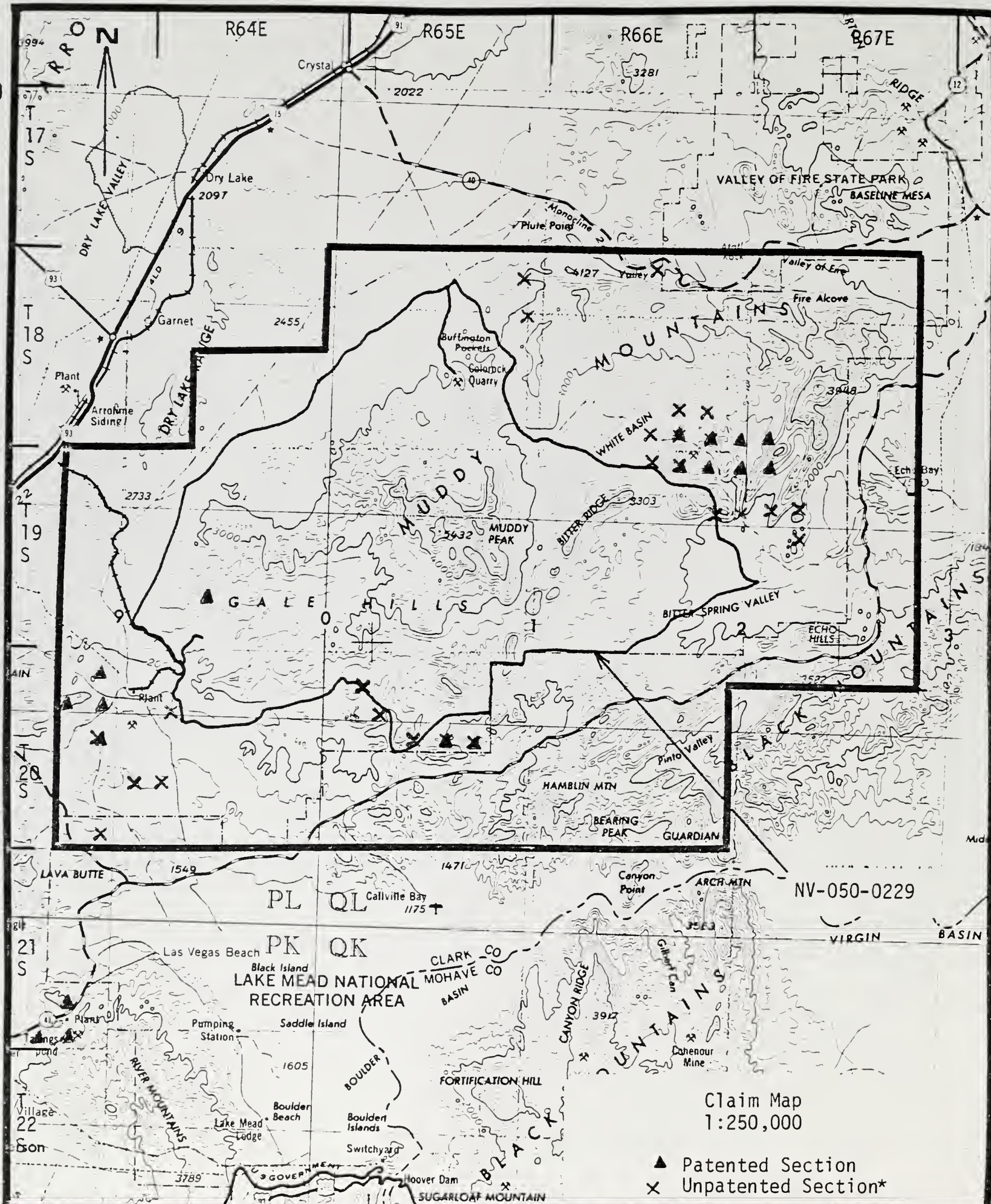
Webb, George, 1982, Chevron Oil, Personal Communication with Dennis Bryan, December 8, 1982.

Webster, G. D., 1966, Biostratigraphy of the pre-Desmoines part of the Bird Spring Formation, northern Clark and southern Lincoln counties, Nevada: Unpub. Ph.D. dissertation, Univ. California, 268 p.

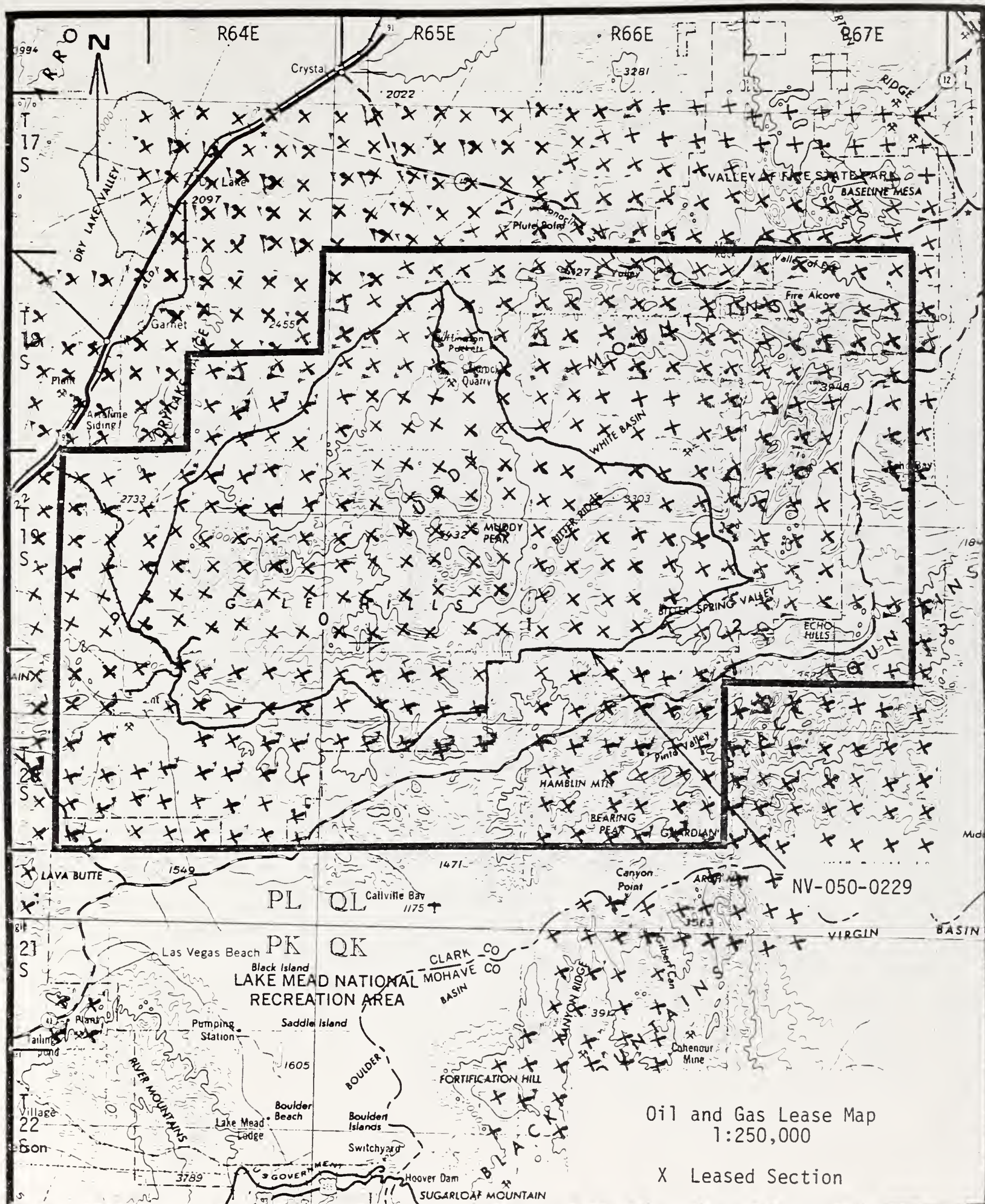
Western Oil Reporter, June 1980, Frontier wildcats aim at thrust belt pay zones.

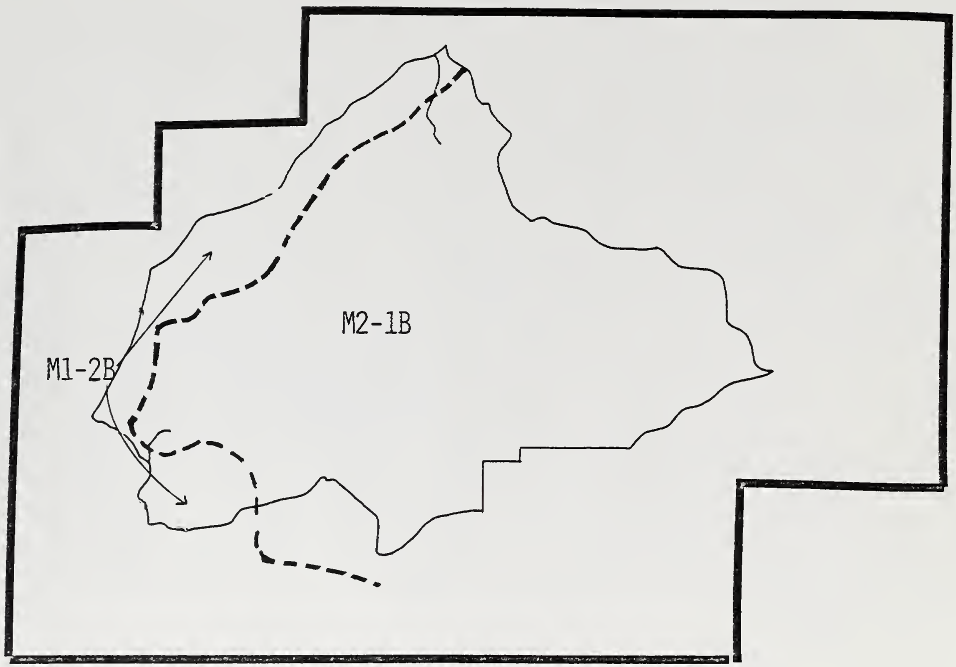
Wood, Bob, 1982, with Pabco Gypsum, Personal cummunication with Diana Pocapalia, December 16, 1982.

Wyman, Richard, 1982, Personal communication with Dennis Bryan.



*X denotes one or more claims per section


N
R64E
R65E
R66E
R67E
T 17 S
T 18 S
T 19 S
T 20 S
T 21 S
T 22 S
Crystal
DRY LAKE VALLEY
Dry Lake
Garnet
Apex
Arrolime Siding
VALLEY OF FIRE STATE PARK
BASELINE MESA
Piute Point
Fire Alcove
WHITE BASIN
BITTER RIDGE
MUDDY PEAK
BITTER SPRING VALLEY
ECHO HILLS
HAMBLIN MTN
BEARING PEAK
Pinto Valley
LAVA BUTTE
Callville Bay
Canyon Point
NV-050-0229
VIRGIN
BASIN
PL
QL
PK
QK
Las Vegas Beach
Black Island
LAKE MEAD NATIONAL RECREATION AREA
CLARK CO
MOHAVE CO
Saddle Island
Pumping Station
RIVER MOUNTAINS
BOULDER
FORTIFICATION HILL
Boulder Beach
Boulder Islands
Lake Mead Lodge
Switchyard
Hoover Dam
SUGARLOAF MOUNTAIN
Cohenour Mine
Oil and Gas Lease Map
1:250,000
X Leased Section



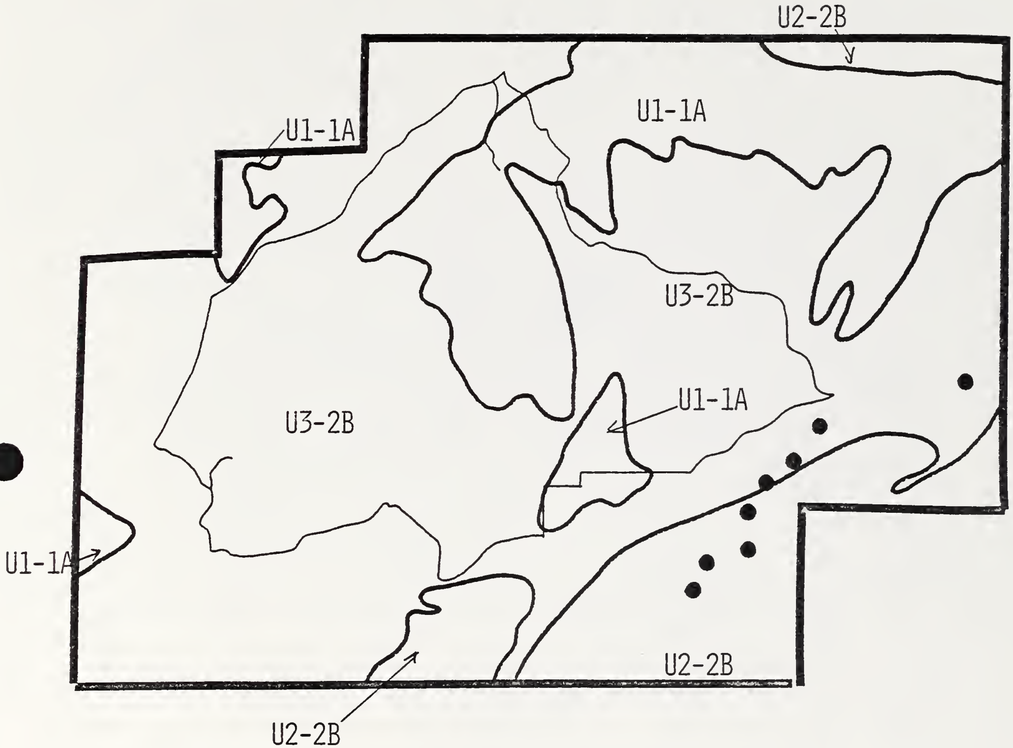
EXPLANATION

- - - Land Classification Boundary

—— WSA Boundary

Land Classification - Mineral Occurrence Map/ Metallics

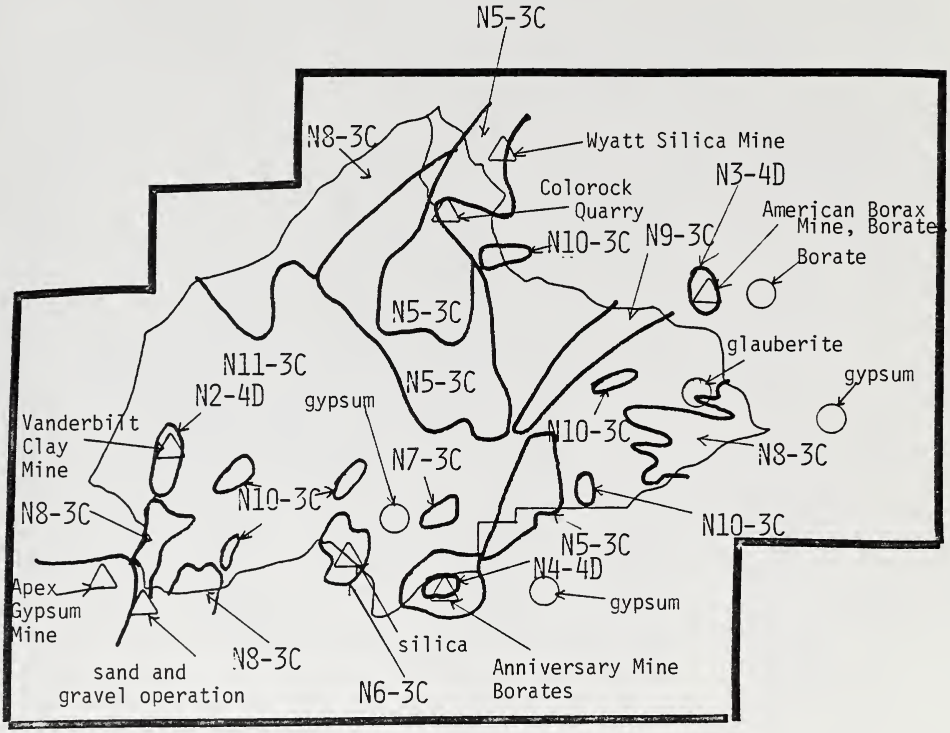
Muddy Mountains GRA NV-34
Scale 1:250,000



EXPLANATION

- Uranium Occurrence
- Land Classification Boundary
- WSA Boundary

Land Classification - Mineral Occurrence Map/Uranium Muddy Mountains GRA NV-34
Scale 1:250,000



EXPLANATION

△ Mine, commodity

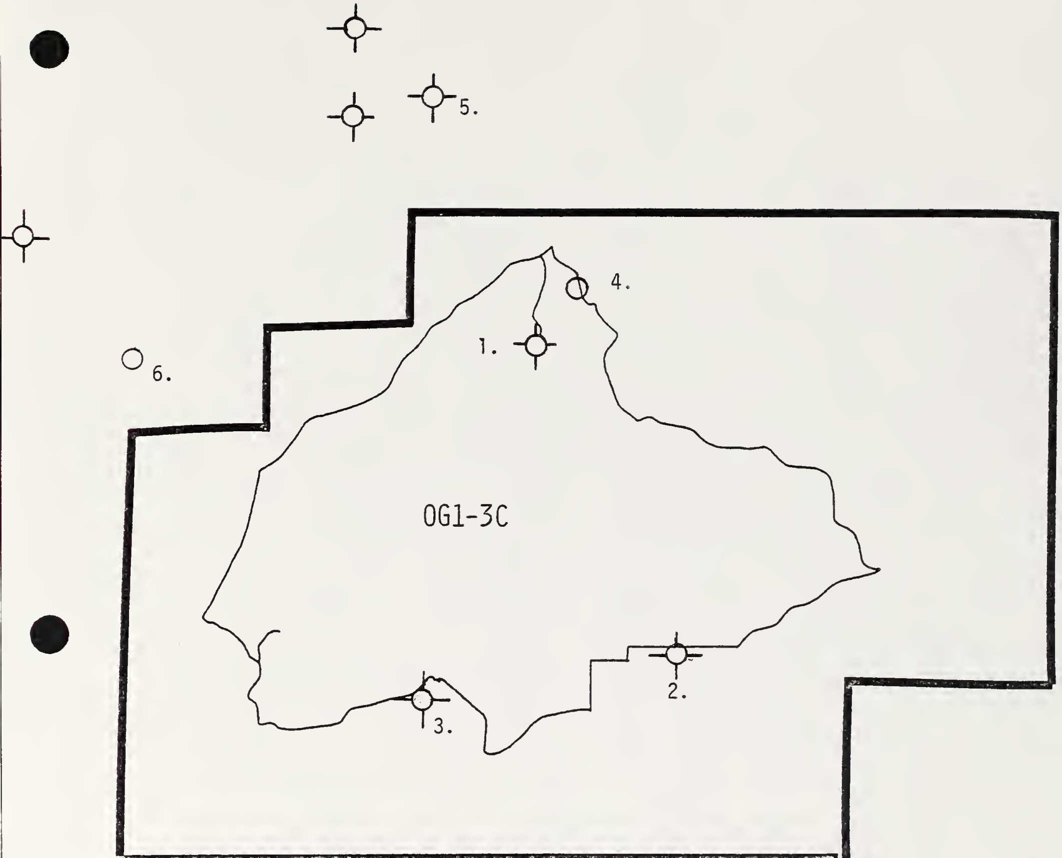
○ Occurrence, commodity

▬ Land Classification Boundary

── WSA Boundary

Land Classification - Mineral Occurrence Map/Nonmetallics

Muddy Mountains GRA NV-34
Scale 1:250,000



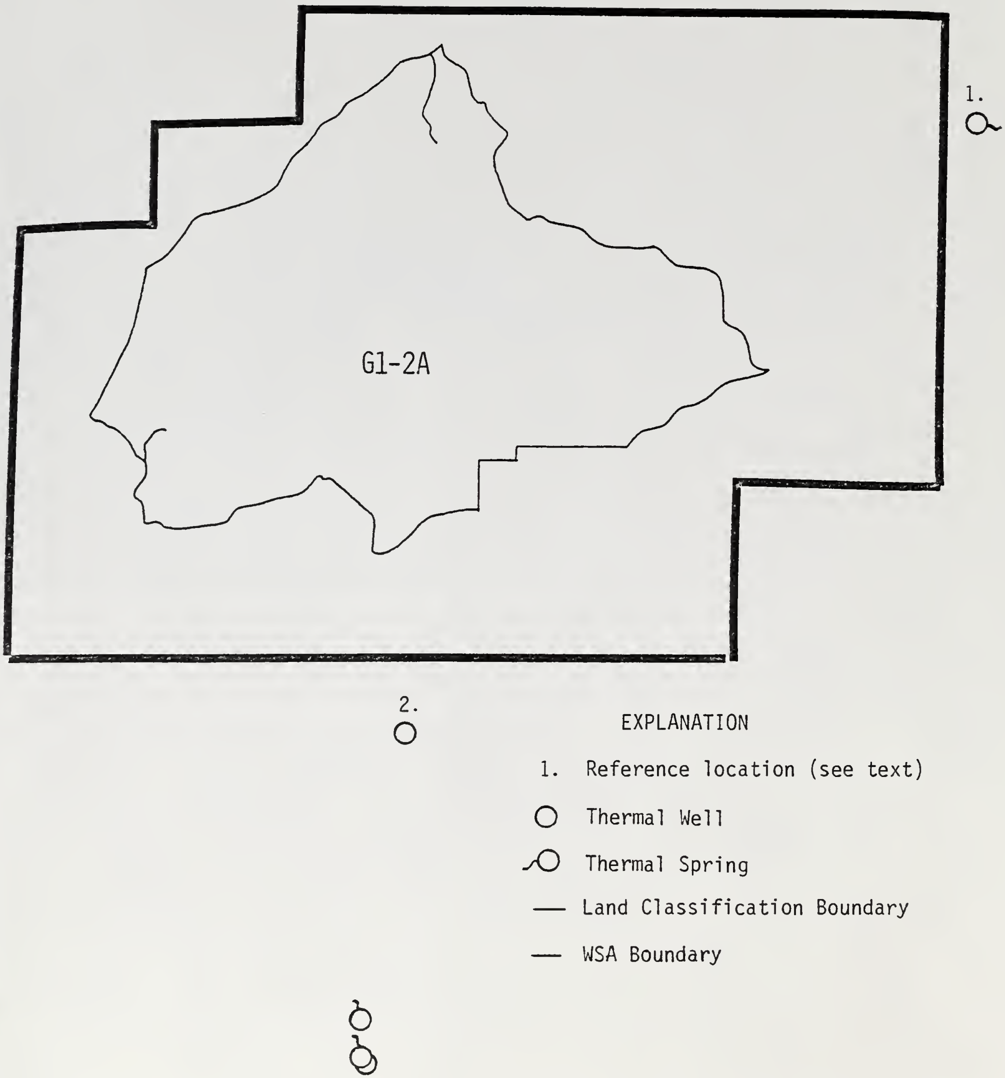
EXPLANATION

1. Reference location (see text)

Dry hole ○ Location

WSA and Land Classification Boundary

and Classification - Mineral Occurrence Map/Oil & Gas Muddy Mountains GRA NV-34
Scale 1:250,000



Muddy Mountains GRA NV-34

Land Classification - Mineral Occurrence Map/Geothermal Scale 1:250,000

LEVEL OF CONFIDENCE SCHEME

A. THE AVAILABLE DATA ARE EITHER INSUFFICIENT AND/OR CANNOT BE CONSIDERED AS DIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES WITHIN THE RESPECTIVE AREA.

B. THE AVAILABLE DATA PROVIDE INDIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

C. THE AVAILABLE DATA PROVIDE DIRECT EVIDENCE, BUT ARE QUANTITATIVELY MINIMAL TO SUPPORT TO REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

D. THE AVAILABLE DATA PROVIDE ABUNDANT DIRECT AND INDIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

CLASSIFICATION SCHEME

1. THE GEOLOGIC ENVIRONMENT AND THE INFERRED GEOLOGIC PROCESSES DO NOT INDICATE FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

2. THE GEOLOGIC ENVIRONMENT AND THE INFERRED GEOLOGIC PROCESSES INDICATE LOW FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

3. THE GEOLOGIC ENVIRONMENT, THE INFERRED GEOLOGIC PROCESSES, AND THE REPORTED MINERAL OCCURRENCES INDICATE MODERATE FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

4. THE GEOLOGIC ENVIRONMENT, THE INFERRED GEOLOGIC PROCESSES, THE REPORTED MINERAL OCCURRENCES, AND THE KNOWN MINES OR DEPOSITS INDICATE HIGH FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

MAJOR STRATIGRAPHIC AND TIME DIVISIONS IN USE BY THE U.S. GEOLOGICAL SURVEY

Erathem or Era	System or Period	Series or Epoch	Estimated ages of time boundaries in millions of years
Cenozoic	Quaternary	Holocene	
		Pleistocene	2-3 [1]
	Tertiary	Pliocene	12 [1]
		Miocene	26 [2]
		Oligocene	37-38
		Eocene	53-54
		Paleocene	65
Mesozoic	Cretaceous [4]	Upper (Late) Lower (Early)	136
	Jurassic	Upper (Late) Middle (Middle) Lower (Early)	190-195
	Triassic	Upper (Late) Middle (Middle) Lower (Early)	225
Paleozoic	Permian [4]	Upper (Late) Lower (Early)	280
	Carboniferous Systems: Pennsylvanian [4]	Upper (Late) Middle (Middle) Lower (Early)	
	Carboniferous Systems: Mississippian [4]	Upper (Late) Lower (Early)	345
	Devonian	Upper (Late) Middle (Middle) Lower (Early)	395
	Silurian [4]	Upper (Late) Middle (Middle) Lower (Early)	430-440
	Ordovician [4]	Upper (Late) Middle (Middle) Lower (Early)	500
	Cambrian [4]	Upper (Late) Middle (Middle) Lower (Early)	570
Precambrian [4]		Informal subdivisions such as upper, middle, and lower, or upper and lower, or younger and older may be used locally.	3,600+ [3]

[1] Holmes, Arthur, 1965, Principles of physical geology: 2d ed., New York, Ronald Press, p. 360-361, for the Pleistocene and Pliocene, and Obradovich, J. D., 1965, Age of marine Pleistocene of California: Am. Assoc. Petroleum Geologists, v. 49, no. 7, p. 1087, for the Pleistocene of southern California.

[2] Geological Society of London, 1964, The Phanerozoic time-scale; a symposium: Geol. Soc. London, Quart. Jour., v. 120, supp., p. 260-262, for the Miocene through the Cambrian.

[3] Stern, T. W., written commun., 1968, for the Precambrian.

[4] Includes provincial series accepted for use in U.S. Geological Survey reports.

Terms designating time are in parentheses. Informal time terms early, middle, and late may be used for the eras, and for periods where there is no formal subdivision into Early, Middle, and Late, and for epochs. Informal rock terms lower, middle, and upper may be used where there is no formal subdivision of a system or of a series.

GEOLOGIC NAMES COMMITTEE, 1970